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NATURAL HISTORY STUDIES

Natural History Studies

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ANDREW MELROSE, LTD.
LONDON & NEW YORK.

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SPRING

NUMBER I

SPRING

IS not April the month of opening? The earth that has been frost-bound opens, and the seedlings lift their heads, drowsily nodding, bending and bowing to the different points of the compass. The buds open and the leaves unfold. The spring flowers open and the newly awakened insects visit them. Surely April is the time of opening—of the earth, of the seeds, of the buds, of the flowers, of the eggs, of the song of birds, and of the heart of man.

The birds who left us last summer, changing their season in the night, and "wailing their way from cloud to cloud down the long wind," have returned rejoicing with spring in their voices. Whether it be the naughty cuckoo, or the dove among the elms, or the nightingale melodious, or the lark at heaven's gate—everywhere from the orchestra which gathers strength every day we hear: "Hither, my love, here; here I am, here; the winter is over and gone; arise, my love, my fair one, arise, and come away."

The Sleeping Beauty has been kissed awake

again. One after another had striven in vain to win a way through the barriers which encircled the place of her sleeping; but at length the Prince and Master came, to whom all was easy—the sunshine of the first spring day. And as he kissed the Beauty, all the buglers blew, both high and low, the cawing rooks on the trees, and the croaking frogs by the pond, each according to his strength and skill. All through the palace there was reawakening: of the men-at-arms—we call them bears and hedgehogs; of the night-watchmen, known to us as bats; not to speak of the carpet-sweepers, like the dormice and hamsters—all were reawakened. The messengers went swiftly forth: the dragon-flies like living flashes of light; the bustling humble-bees, stopping to refresh themselves at the willow catkins by the way; the moths flying softly by night on secret service. How accurate the old stories are: "The scullery-boy got a long-delayed box on the ear when the cook awoke"; the wood-snail drew in his horns as the thrush swept swiftly by.

These spring days are the days of youth—of seedlings, buds, and fresh blossom, of tadpoles, nestlings, and lambkins: of which, as of children, there are two thoughts which we cannot help thinking.

The first is a thought of Easter, of the forgiveness of Nature, of its power of making a fresh start. In autumn we saw the vine robbed of all its leaves—transfigured in their dying—and hard-bound by the frost; but now the tender vines put forth a

sweet smell. We saw the sloe in winter, bare as a skeleton in the desert, but black; we see it now covered with white blossom, which we almost mistook for snow unmelted. We saw the hedger strip the hawthorn till it was pitiful in its nakedness; we see it now covered with bursting buds, and it will soon be the time of May-blossom. From amid the withered leaves the wood-anemones are rocking like foam-balls on a wreck-strewn sea; and from the ditches, just the other day black, empty and uninviting, the marsh marigolds have raised their golden cups—their king-cups—to be filled with sunshine. We wished the birds farewell in autumn as they passed overhead to lands that keep the sun, and now they are gathering around us again, and every swift's scream seems a shout of victory. Every lark in the meadow sings a promise. The butterflies seemed to fade away with the withering flowers, but their successors are flitting by. The shore-pools seemed but a little while ago empty of life, and the ponds were thickly frozen over, or sullen at all events, but now each is beginning to be like a busy city. For as surely as the old things pass away, so all things are made new. From what seemed a sealed tomb, life has arisen indeed.

But there is a deeper sense in which these are the days of new things. Spring is the time of marrying, pairing, and mating. It is the time of giving birth to new lives. It is the time when new lives, begun long since, indeed begin to live. In all these young lives there is what is new; no

one of them is quite like its parents, but each carries with it a promise. It may be that the promise is never fulfilled, for the playful lamb grows into a very stolid sheep; the very active-minded chick becomes a most matter-of-fact hen. But if the promise be fulfilled, then the world makes progress, and that is Spring.

NUMBER II

WATER-BABIES

SPRING is the season of young things—of seedlings, buds, and young blossom, of tadpoles, nestlings, and young lambs. It is the time of new beginnings, of hopes and promises; it is the time when all the world is young.

One of the great events of spring which we are apt not to notice is the multiplication of minute living creatures in the waters. They swarm with water-babies. Sometimes the whole surface of the lake is green with minute plants, and we speak of "the breaking of the meres." The same is true of pond and river, of estuary and sea; the multiplication of minute creatures is the prelude to the general renewal of life. A single infusorian may be the ancestor of a million by the end of a week; water-fleas eat the infusorians; fishes eat the water-fleas; and we eat fishes. Everywhere there are these long chains, like the House that Jack Built.

Young gnats and mosquitoes are among the many very interesting "water-babies" to be found in stagnant freshwater pools in spring. The mother

insect, who has spent the winter in hiding, lays two or three hundred eggs on an early morning in spring. She does so in such a way that they form a tiny raft—about a quarter of an inch across—which floats on the surface of the pool, and can neither be sunk nor wetted. Each egg is somewhat cigar-shaped, with the upper end pointed, and the lower end with a lid, which opens to let the larva out into the water. The larva spends most of its time hanging head downwards from the surface-film, through which it raises its breathing-tube. Very delicate hair-like organs sweep microscopic particles into the mouth. If you push the larva below the surface it sinks to the bottom, but it soon jerks itself up again tail foremost. There are no limbs, but the tail part strikes the water vigorously, and there are tufts of bristles on the sides of the body.

The larva feeds and grows and moults, and after three or four moults it is full-grown—almost half an inch in length. It then passes into a pupa stage, very different from the larva, and within the pupa-skin the change from larval to adult structure, which has been in progress for some time, is accomplished. The pupa has a strange shape, with a big "head-end" that seems all out of proportion, and with a paired paddle at the hind end. It rests at the surface, head upwards, breathing by two horn-like or trumpet-like tubes. It does not eat at all, and when it is alarmed it has to dive forcibly downwards, so buoyant is its body. After three or four days of pupa-hood the cuticle or outer

husk splits along the back, the limbs are pulled out of their sheaths, and the gnat comes forth, not without risk and difficulty. It rests for a short time, standing on its own husk, and then flies off into a very different world. The whole period of development is about a month, and there may be many successive broods. Every one knows how fond the females are of blood; the males feed daintily on nectar, if they feed at all, and spend most of their short life in aerial dances.

When we peer into the pools where the young gnats live we get a picture of the abundance of life, especially in the spring-time. It is an impression for a lifetime to go into a fish-hatchery and see the rows of rocking cradles in which the young fry are swarming, perhaps a hundred thousand in one box. But from many different sides we get the same picture—thousands of tadpoles in the ditch, countless swarms of grubs and caterpillars on land, clouds of mosquitoes and midges rising from the marshes, hundreds of seedlings from one oak tree, an innumerable army of lemmings mustering in the valleys of the Tundra. Life is like an inexhaustible fountain—a spring.

NUMBER III

THE TALE OF THE TADPOLES

FROGS are among the earliest heralds of the spring, for although their croaking (in March or earlier) may not be particularly attractive to our ears, it has the same meaning as the nightingale's song. It is a "love" call. Awakening after a long rest and a long fast, the frogs creep out of the mud of the pond and call to one another. They unite in couples, and the eggs laid by the female in the water are fertilized by the male just as they are laid. These eggs form the masses of "frog-spawn" that we see in the ditches and ponds.

Perhaps we may be fortunate enough to see with a pocket-lens the eggs dividing into two, four, eight, and more cells, as if they were being cut by an invisible knife. Each egg in our common British frog is about a tenth of an inch in diameter; it is almost entirely black, all but a small white lower pole; it is surrounded by a large sphere of non-living jelly, corresponding to the white of egg in a hen's egg; but there is no egg-shell. The whole mass, often of 2,000 eggs, sinks at first, but afterwards floats freely.

The spheres of jelly buoy up the eggs and at the same time prevent overcrowding. In the little chinks between the spheres there are often groups of microscopic green plants which liberate oxygen in the sunlight and use up the carbonic acid gas which the developing eggs produce—a profitable association, a miniature illustration of the Balance of Nature. But there is a fauna as well as a flora of frog-spawn, and the chinks are tenanted by small fry—such as water-fleas and rotifers—some of which eventually loosen the gelatinous envelopes, helping the larval-frogs to escape. Others, it must be admitted, seem to wait to devour. And again, the envelopes of jelly are useful in lessening the risks of jostling—which might be fatal to the delicate embryos—when the wind raises waves in the pond, or when a water-hen or coot splashes in among the spawn. Moreover, the jelly seems to be unpalatable to most water animals, and it is so slippery that few birds can make anything of it. Finally, it may be that the clear spheres serve as so many greenhouses, helping the ova to make the most of the sun's rays.

The Hatching

About a fortnight or three weeks after the eggs were laid and fertilized, the minute larvæ are hatched from the delicate envelope of the ovum, and begin to wriggle about in the dissolving jelly. They are somewhat awkward-looking, half-made creatures at first, and when they get clear of the jelly they are mouthless, limbless, eyeless, and gill-less. They attach themselves, often in long rows, to water-weed,

by means of a paired cement gland below the place where the mouth will appear. A bulging on the under surface of the body shows the position of the still unused remains of the yolk.

Soon after hatching, three pairs of external gills grow out, the first much the largest, one upon each of the first three gill arches. One or two days after hatching the mouth appears in the centre of a groove in front of the adhesive organ, and hundreds of small horny teeth are formed. When the food-canal becomes open, four pairs of gill-clefts break out from the pharynx, and a gill-cover overlaps the first set of gills. These dwindle and are absorbed, their place being taken by a second set of gills supported by the lower halves of four gill-arches.

The Fish-likeStage

About a month after hatching the larval frog is in many ways fish-like : for instance, it has a two-chambered heart which drives impure blood to the gills, which are enclosed by a gill-cover. It swims by its laterally compressed tail, which shows a well-developed unpaired fin, without fin-rays, however, which are always present as supports for the unpaired fins of fishes. *In a very general way* it may be said that the developing frog visibly climbs up its own genealogical tree. But what took the race of frogs long ages to accomplish is achieved by the individual in a few days—a fact so familiar that we are apt to forget its marvellousness.

With the acquisition of a mouth the larva begins

LIFE-HISTORY OF FROG.

to feed eagerly, nibbling at plants in the water, and also eating animal food. As a consequence it grows, and the food-canal, in particular, becomes very long and coiled like a watch-spring. As the tail becomes stronger and the power of locomotion increases, the horseshoe-shaped adhesive organ is converted into two small discs which gradually disappear.

Different Stages of Tadpoles

A new stage is marked by the appearance of the hind-limbs as minute projecting buds at the boundary between trunk and tail. The fore-limbs are delayed by the gill-cover, which does not impede the hind-limbs, but they eventually emerge, the left one through the breathing-hole, the right one by a breakage.

After the appearance of the hind-legs, the larvæ come often to the surface to breathe. They are learning to use their lungs, which have been slowly developing for some time as pockets projecting into the body-cavity from the under side of the gullet. The tadpoles are now about two months old, and in having lungs as well as gills they may be compared to the double-breathing mud-fishes or Dipnoi. As the lungs begin to be used, the gills dwindle away, and the fish-like heart and circulation become those of a frog.

From Tadpole to Frog

After a period of hearty feeding, with consequent increase in size and strength, the tadpole begins

to show signs of a great change. It loses its appetite, it becomes much less energetic. The tail begins to break up internally, its muscles and other structures are dissolved, and most of the material is swept away in the blood stream to help in building up a better head. Wandering cells, which are present in almost all animals, seem to play an important part, working like sappers and miners among the debris of the tail, dissolving some of the material, carrying some away. In the course of the great change, the horny jaws are lost, the frilled lips shrink, the mouth changes its shape and becomes broad, the tongue becomes large and movable, the eyes, hitherto hidden beneath the skin, become clearly visible.

As the tail shortens more and more, the tadpole, rapidly ceasing to be a tadpole, recovers its appetite and feeds greedily on animal matter, sometimes on its younger fellows. The tail is reduced to a short projecting stump, and, apart from this, the adult shape has been reached. Disinclination for a purely aquatic life becomes marked, and the young frogs clamber ashore. As they have lost all trace of gills, they are apt to drown in aquaria unless they have floating rafts to climb upon, or some other means of breathing dry air.

The Frog's Year

Before leaving the tadpoles, interesting in so many ways, let us think over the year's life of the frog. Throughout the winter months the frogs

lie near the pond, buried in the mud or safe in secluded holes, mouth shut, nose shut, eyes shut, with the heart beating feebly, breathing through their skin, and eating nothing. The awakening in spring is followed immediately by pairing and egg-laying, and the aquatic juvenile life of the tadpoles occupies about three months. In summer there is a remarkable migration to the fields and meadows, and many hundreds of froglings, about the size of a first-finger nail, are seen on the march from the pond. The adults also migrate, and the meaning in both cases is the same—that they seek out places where insects abound. Of the many that go forth, only a remnant returns, for there is great mortality in the fields, where there are many physical risks and many alert enemies. The grass snake alone accounts for a good many in some parts of England. Those that escape—whether youngsters or old experienced hands—return to the pond in the autumn, and go into winter quarters in the mud.

NUMBER IV

CATERPILLARS

THE sight of the first butterflies is always gladdening, for it means that summer is setting in. Most of these early butterflies have spent the winter as chrysalids or pupæ, hidden away in sheltered retreats. They emerge and pair; the females lay their eggs; these develop into the caterpillars which are often so abundant in the summer months.

Structure of a Caterpillar

A typical caterpillar—the larva of a butterfly or a moth—shows a hard polished head and a body of thirteen rings. The head is strengthened by a median shield and two side-plates bearing half a dozen simple eyes and minute three-jointed feelers—in marked contrast to the large compound eyes and long feelers of the adults. In the service of the mouth there are three pairs of minute jaws, on the third of which there is in many cases a spinneret from which a jet of liquid silk flows out, hardening in a moment into a thread. The caterpillars use the silk to attach themselves to twigs, to save themselves when they are about to fall, to lower themselves from a branch to the ground, and to make a cocoon for the period of their great change.

But there are many caterpillars that are not silk-spinners.

Returning to the structure of the caterpillar, we see that each of the first three rings behind the head bears a pair of five-jointed legs ending in a claw. Behind this region there are ten rings, but in most cases the ninth is telescoped and difficult to see. Short unjointed legs, ending in peculiar gripping structures, occur on the third, fourth, fifth, and sixth of these rings, and a large pair (sometimes changed into protrusible whips) is borne on the tenth and last. There are, of course, many departures from the rule that there are five pairs of these unjointed legs or "pro-legs." Thus in the "loopers," which move in a characteristic way, familiar in the common magpie moth, there are only two pairs.

There are paired breathing apertures, leading into air tubes, on many of the rings, and the body is often thickly covered with hairs, bristles, spines, or warts. Inside the body there are, of course, organs corresponding to those that we possess—brain and nerve cord, food-canal, muscles, air-tubes, heart, and so on.

Activities of Caterpillars

Most caterpillars lead an active life, moving about in search of food. Some rove by day and others by night. In some dim way they are aware of the suitable food-plants, passing others by, and certain kinds may often be seen exploring in a business-like fashion. The procession caterpillars, which

feed and rest together in a huge common web, go on the march in large numbers, sometimes in single file, sometimes in broad ranks. In the Italian Riviera one of the procession caterpillars makes a great silken shelter on the branches of the Aleppo pine, and often eats them quite bare, doing great damage. They are checked a little by the larva of a beautiful beetle which forces its way into the silken nest and destroys the inmates. These procession larvæ may be seen on the march in spring, forming long lines on the road, the head of one almost touching the tail of another. As they go they sometimes secrete a composite thread, continuous to their headquarters on the tree. It has been shown that they instinctively follow the leader, and that he may give up his position in favour of another. Schoolboys sometimes make a circle of the procession, the head of the leader being brought to touch the hind end of the last on the file, and such a circle has been known to go on circling for days—a fine example of the difference between intelligence and instinct. In their procession the caterpillars are seeking for a suitable soft place in which to bury themselves for their great change. When they find it, they mass together, and move round and round paying out silk and loosening the soft soil. In this way they gradually sink below the ground, where they lie dormant, slowly changing into moths which come out in autumn.

It may be noted that the loosely attached hairs of the procession caterpillars are covered with

fine hooklets, and are very irritant to many people and not at all to others. They give rise to "sore throats" if they are breathed in, or they cause a rash on the skin when the caterpillars are handled.

Appetite of Caterpillars

Another feature in the life of caterpillars is their enormous appetite. Some of them seem never to stop eating, and some of them eat many times their own weight in a day. The contrast between this and the dainty meals of the butterfly or its not infrequent fasting is very striking. The caterpillar is the feeding, growing stage; the moth or butterfly does not grow at all and often eats very little. In the great majority of cases caterpillars are vegetarian, and it seems that they can digest only the fluid parts of their food, which sheds some light on the enormous quantity eaten.

The extraordinary voracity of caterpillars is associated with rapid growth, and this with periodic "moulting." As in the other jointed-footed animals (such as centipedes, spiders, and crustaceans), the body is covered with a husk or cuticle—a layer not in itself living, made by the underlying living skin. It is really like flexible armour; it cannot grow, and it has little expansibility. Therefore, as the caterpillar grows, it is continually becoming too large for its clothes, and therefore these have to be moulted. Five moults very frequently occur. Every moult is extraordinarily thoroughgoing, involving all the many intuckings of the outer

layer, and the caterpillar is out of sorts at every moult. There seem to be serious breathing difficulties, and there is something like inflammation. The moult is a serious business, and often ends fatally.

The Pupa or Chrysalis

After the caterpillar has reached its limit of growth it passes into a resting phase, which is often prolonged for many months. It becomes a pupa, nymph, or chrysalis, and undergoes the great change, which is always called the metamorphosis. In many butterflies and some small moths, the larva fastens itself by its tail to a twig ; in many other cases it suspends itself by a silken thread ; some hide between two leaves fastened together by silk ; many burrow beneath the ground ; most moths make some sort of cocoon or shelter, which may be of pure silk neatly wound, or of silk mixed with hair and all manner of external things—such as pieces of leaf, bark, moss, and lichen, and even grains of earth. These cocoons are usually constructed in sheltered corners, and are often very inconspicuous. The finest pupa-cases are surely those which are spun of silk (in most moths), and the making of them in a few days shows great internal activity on the part of the silk glands, and also great muscular activity on the part of a creature that is about to fall into sleep. The long thread of silk is spun into a well-made sleeping sack by persistent movements of the head, and this may require hundreds of thousands of movements.

The Great Change

Within the cocoon the body of the larva is broken down and is built up again on a new architectural plan. Clusters of active cells become the centres of new formation, and wandering cells, working like sappers and miners, transport material from place to place. Although the breaking-down which precedes the reconstruction is never so thorough-going as in flies, where the pupa returns almost to an egg-like state, there is a gradual change of almost all the organs. One may compare what occurs to a not unfamiliar sight, the piecemeal pulling down of a large building, such as a railway station, and its piecemeal rebuilding, all so arranged that the activity—and what is life but activity ?—does not come to a standstill.

When the reconstruction is completed—which may take a couple of weeks or as many years—the fully formed insect emerges from the pupa-case—its last moult. It is often rather soft and flabby on its emergence, but it soon hardens up and there is no more growing. Many of the details of the liberation of the butterfly or moth are extremely interesting, thus there are often lids which open neatly ; there is sometimes a special "case opener" that helps the escape, just like the "egg-tooth" with which young birds break through the egg-shell ; the puss-moth secretes caustic potash from its mouth which dissolves away the pupa-case.

The Defences of Caterpillars

The ranks of the caterpillars are thinned by the weather, by many birds, and by other harassing enemies, such as the ichneumon flies which lay their eggs in the juicy body. The risks that caterpillars run are so many that their survival is sometimes surprising. In the main it is secured in two ways—by sheer force of numbers and by many different peculiarities which protect the caterpillars not merely from being swallowed, but from being pecked at. For even a slight wound may be very dangerous to a plump caterpillar. Hairy caterpillars are left alone by most birds, though the cuckoo seems to relish them. Not a few give out offensive fluids, such as formic acid, when they are touched. Some have an unpleasant smell, and others are unpalatable. Some hide during the day, others play 'possum when touched. Some lash with their tail whips and strike "terrifying attitudes." Many have come to resemble things that are safe; thus some are extraordinarily like stunted twigs or little knobs on a stem; others are like little splinters of wood or the curled margins of withered leaves; others are coloured like the flowers they feed on.

The True Inwardness of Caterpillars

But of all the interesting things about caterpillars the most remarkable is the central wonder —the great change by which the crawling larva is broken down and built up again on a new plan,

that of the winged moth or butterfly. The true inwardness of the remarkable story is perhaps this, that the full-grown butterfly or moth is usually an intensely active creature, which eats little or nothing, grows not at all, but lives for love. The prolonged caterpillar stage in which there is much eating and much growing is one in which stores are accumulated for a much higher kind of life. When the life of preparation is drawn out over more than the summer, the quiescent pupa-stage, well wrapped up, makes it easier to survive the winter. The caterpillar and the chrysalid together make the butterfly possible.

NUMBER V

THE NATURAL HISTORY OF NESTS

NEST-MAKING is so characteristic of birds that we always think of "bird" and "nest" together. But birds are by no means the only creatures that build nests. The squirrel makes a big nest of moss, leaves, and grass at a fork between two branches of a tree or in a hollow of the stem. The father stickleback glues together the filaments of seaweed and makes a serviceable nest, in which his mate lays the eggs. Many spiders make true nests of silk, while others bind leaves together with silken threads. The wasp's familiar construction is a house as well as a nest. There are many other nest-makers, but it is among birds that nest-making reaches its greatest perfection, variety and beauty.

Uses of Nests

The uses of nests are manifold. First, they often secure the safety of the eggs and young birds by being inconspicuous or by being inaccessible. The period of development and of helplessness lasts about a fortnight in many finches, three weeks in the fowl, over a month in petrels, towards six weeks

in the swan, and over seven weeks in the condor, and the risks of discovery are often great. The nest means safety. Secondly, the eggs and the young take on the temperature of the surrounding world, and when they cool below a point, which differs for different kinds, they cease to develop and soon die. The nest often economizes the animal heat of the brooding bird, so that there is little waste. It is also evident that the nest is convenient for feeding purposes, and as a temporary prison for the nestlings, so that they are less likely to make rash excursions. Sometimes the nest serves for a certain amount of home-education. Furthermore, the nest is often a comfortable and secure resting-place for the parent birds.

A Series of Nests

Let us survey the series of nests from the simplest to the most complex. We naturally begin with those birds in which the nest-building is "scamped" or shirked.

The tern makes no more than a mere scraping on the gravelly sand. It is the same with divers, thick-knees, sand-grouse, and many other birds. In the case of guillemots and razorbills, the egg is laid on a bare ledge of rock, and the top-like shape is to some extent a safeguard against being blown over or knocked over.

Many of the gulls, sandpipers and plovers simply lay their eggs in shallow hollows in the ground, adding a breastwork of stems and leaves as brooding proceeds. The ducks are mostly about the same

level of nest-making, but their depression is lined with down. The ringed plover lays its eggs on the shingle, where they are so like rounded pebbles that they are most effectively lost to ordinary vision. One of the most charming of ground nests is that of the eider-duck, where a thick quilt of down is accumulated that can be drawn over the eggs when the mother-bird goes down to the sea for food.

In not a few birds the only care is to bury the eggs—a way of securing their safety that recalls suggestively the habits of some reptiles, such as crocodiles, which are historically antecedent to birds. The New Zealand kiwi puts its single big egg in a hollow at the base of a tree-fern; the female ostrich lays her eggs in a hole which the cock scrapes in the sand, and both birds share in brooding. Some mound-birds bury their eggs in the sand and leave them, while others heap a huge hot-bed of dead leaves over the spot.

Grebes and some rails collect pieces of water-plants and "form of them a rude half-floating mass, which is piled on some growing water-weed"; and while they do not shirk incubation, they seem to trust partly to the heat of decomposition.

We gradually work up from ground-nests to the earth-mounds on which the flamingos sit, and on to rough platforms like that of the wood-pigeon, through the floor of which the eggs may be seen from below. Making a fresh start, we reach the more elaborate stick nests of the rooks and crows; from these we pass to the heron's, where a little

NESTS.

Long-tailed Tit and its Feather-lined Nest.

bedding is added; or to the magpie's, where the erection is fenced round with thorns.

An offshoot in a different direction is represented by birds that make burrows or tunnels or excavations of some sort, getting as far as possible into private life. In its safe retreat the sand-martin makes a scant bed of roots and feathers collected from far and near. The kingfisher makes a stranger one of undigested fish-bones. Sheldrakes and puffins often utilize rabbit-holes. The woodpeckers carve out holes in decaying trees; the nuthatch plasters up part of the doorway. In the case of the hornbills, the female is weakly and moulting at the breeding-time, and the male shuts her into a hole in a tree-stem. The floor may have to be deepened, or it may have to be raised with dry earth from the termitaries. The doorway is built up, too, so that intruders are readily kept out, while the hole is large enough to let the male bird's bill in. It is on him that the labour devolves of finding food for his mate, and afterwards for his family as well. He is often worn thin with his other-regarding exertions, while the female bird becomes fat. Sometimes, the story runs, the male bird dies without having the reward of even seeing his children.

Cases, like that of the hornbill, where there is some building as an accessory to the nest, point the way to definitely built nests, such as those of the swallow and the house-martin. The swallow's is the more primitive of the two—it is made of mud strengthened with pieces of straw; it is like "half a deep dish," open at the top; it is built against

a rafter or a chimney; it has a lining of small feathers and soft grass. The house-martin's is also made of mud, strengthened with pieces of straw or hair; it is built against the wall of a house or against a cliff; it is like a bowl in shape, with its open side against the surface selected, and with a small entrance near the top; there is a lining of feathers, which the martin catches in the air, and pieces of straw. It is difficult to understand how the bowl hangs on to a smooth surface—even to a vertical pane of glass; it is interesting to watch the patient carefulness of the builders, adding about half an inch every morning and no more till next day, so that it hardens well, the whole operations lasting for about a fortnight.

On a different line, though there is no lack of connecting links, are the felt-work nests, cleverly made of interwoven vegetable fibres and hair—in both cases a good non-conducting material. Chaffinch and goldfinch make open felt-work nests, which may be eked out with spiders' webs and often beautifully disguised with moss and lichen. Similar constructions, master-pieces of skill, are domed in the wren and the bottle titmouse, slung like a hammock in the gold-crest, suspended by a string in certain grosbeaks and humming-birds. There seems to be no doubt that the nest is sometimes *balanced* with lumps of earth—an extraordinary device when one comes to think of it.

Among these built nests there are endless refinements of detail. The entrance may be narrowed; the outside may be masked; the whole may be

swung so loosely that no snake could possibly enter; the lining may be made like a bed of down: thus the old Scotch ornithologist MacGillivray counted 2,379 feathers in the nest of the long-tailed tit. In the nest of the common thrush, which is plastered internally with rotten wood mixed with dung, or in the nest of the mistle-thrush, which has a considerable foundation of mud, we have instances of the numerous connecting types between hard-built and felt-work nests. The tailor-birds make a thread of vegetable fibre, and sew together the edges of a couple of leaves; the fantail warbler also uses a thread—knotted at the end—to bind grass-stems into a canopy over its nest.

The series of nests might be greatly prolonged, but we must bring it to a close with a reference to what is perhaps the most extraordinary of all nests —that of the sea-swift. This bird occurs in great numbers in Indian and Australian regions, and usually nests socially in caves, both by the sea and among the mountains. The peculiarity of the nest—the well-known "edible bird's-nest"—is that it normally consists of the dried juice of the salivary glands. When the first nest has been gathered, the bird sometimes builds an inferior type of nest, including a considerable quantity of vegetable matter glued together with the hardened salivary juice.

So we see that there is a long inclined plane from no nest at all to the most elaborate nest, but the important fact is that the character of the nest is peculiar to each particular kind of bird. Each

kind of bird keeps to its own kind of nest—*with much constancy.* The blackbird is first cousin of the thrush, but the nests are very different, and so it is all round.

The Fashioning of the Nest

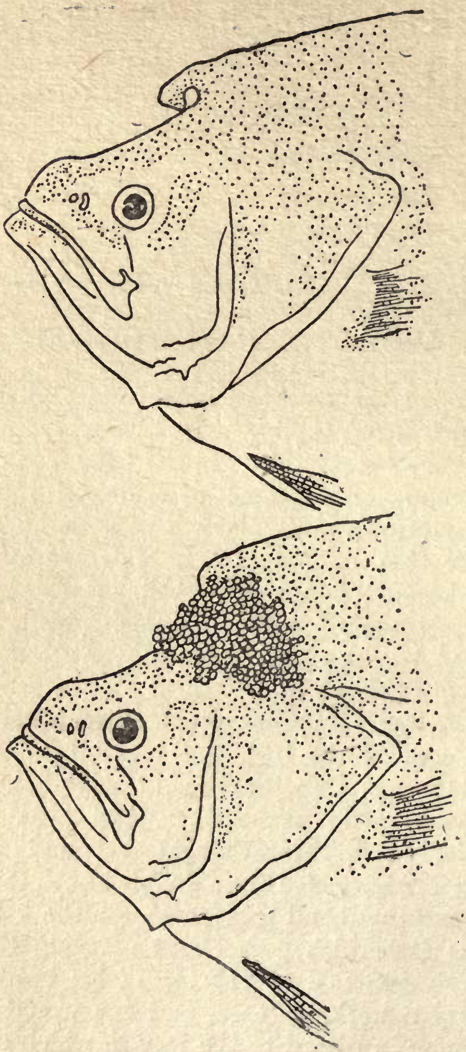
As birds are practically handless—since the arms have been turned into wings—the bulk of the work is done with the bill and with the feet, and the body is used to mould the framework, the bird turning round and round inside the growing nest, making it fitter at every turn with a poke of the bill and a thrust of the foot.

It is not very difficult to observe how a bird uses its bill and feet in fashioning the nest, but it is very difficult to get near the inward spirit. Perhaps it is safe to say that nest-building is in great part an inborn art, that it is *instinctive.* But this does not shut out the possibility that in some cases imitation and a sort of tradition may count for something. Even further it may be possible to go in cases where birds build in very novel places and use very peculiar material, for then perhaps there is a spice of intelligence in their skill.

NUMBER VI

THE STORY OF KURTUS

IN one of the rivers of New Guinea there lives a fish called Gulliver's Kurtus, whose parental care is very remarkable. In the full-grown male a bony process on the back of the skull grows forwards and downwards like a bent little finger, and forms a ring or "eye." In this, somehow or other, a wreath of eggs is attached. Each egg has an envelope made of coiled threads, which unwind when the eggs are laid, and are over a hundred in number. It is as if a ball of thread unravelled itself into many separate pieces, all remaining fixed to the core of the ball, but becoming entangled by their loose ends with those of other balls. The egg-threads unite into strings, and these into a cylindrical band. Thus the eggs are bound together, forming a twin cluster like a double bunch of onions. The connecting band passes through the bony ring and the father-fish goes about carrying the eggs effectively fastened on the top of his head. This is a very remarkable case, and one would like to know more in regard to the way in which the egg-bunches get fastened to the bony ring. What is



Head of the male Kurtus. (*After* Weber.) The upper figure shows the bony hook. The lower figure shows the bunch of eggs caught in the hook.

particularly interesting is not that the father-fish takes care of the eggs, for so do sticklebacks and sea-horses, the particular feature that amazes one is that two quite separate arrangements—the uncoiling and recoiling of the egg-threads and the hook on the top of the father's skull—should fit together so well, and secure *between them* the safety of the developing eggs.

NUMBER VII

PARENTAL CARE AMONG ANIMALS

IN many animals, from worm to frog, the mother liberates a large number of eggs, and leaves them to develop. Sometimes, indeed, as in certain sea-worms and in many butterflies and moths, she dies soon after. Even in strong animals like lampreys and eels, the death of the parents seems to follow close on the heels of giving rise to offspring. It must be admitted that the liberation of huge numbers of ova—sown broadcast in the waters—is a wasteful process. There is great mortality and many of the eggs never begin to develop. The race is continued because there are so many.

It seems then that both from the parents' side and from the offspring's side there is much to be said for parental care, and we see it beginning among many different kinds of animals.

We see a beginning when the mother lays her eggs, instead of merely liberating them. The female salmon lays eggs in a furrow which she makes in the gravelly bed of the stream. We see a beginning when the mother carries her eggs about with her after she has liberated them. Many a spider has a

silken cocoon which she bears about with her until the spiderlings hatch. We see a beginning when the eggs are kept inside the body until they hatch into young ones or until favourable circumstances arise. Thus the mother freshwater mussel keeps her young ones in her gill-cradle until a minnow or some other fish comes conveniently into the vicinity. We see a beginning in the way many an animal

Female Spider—Dolomedes mirabilis—carrying underneath her body, attached by silk threads, the silken cocoon containing the eggs and eventually the young spiders. (*After* Blackwall.)

mother allows her young ones to clamber about her body, holding on to her and being protected by her.

In some cases, both of high and low degree, the parental care is exhibited by the fathers. We find this among interesting animals known as sea-

spiders or Pycnogonids, where the males carry the eggs attached to two of their legs. We find it in several fishes, such as the stickleback, who makes and guards the nest among the seaweed, or the

Sea-Horses, Hippocampus. The upper row shows the successive positions of the body in swimming. The body bends forwards and straightens again. The lower row shows the fishes at rest. (*After* Anthony and Chevroton.)

sea-horse, who carries the eggs about in his breast-pocket. The same is true of some pipe-fishes.

Among Amphibians there are many cases parallel to those which occur among fishes. Thus the male nurse-frog, not uncommon in some parts of the Continent, carries the strings of eggs on his back

and about his hind legs, buries himself in the damp earth until the development of the young ones is nearly complete, then plunges into a pool, where he is freed from his living burden. In the case of the Surinam toad, the male is said to help the female in placing the eggs upon her back, where each sinks into a little skin pocket, in which it develops without passing through a tadpole stage.

In many insects the mothers exert themselves unsparingly to provide stores of food for the young, but help on the father's part is very rare. Among the dung-rolling beetles there are exceptions—such as the Sisyphus, the males and females of which work together in kneading a ball of dung and trundling it, over great difficulties, to the underground burrow where the eggs are laid. In the case of the scarabee, Fabre tells us that while the sexes work together when rolling balls of dung for their own consumption, the female is left to do all the work of moulding the ball and transporting it when it is for the use of the future brood.

It is among birds and insects that we find the finest examples of parental care, but what a contrast there is between the two sets of cases. Among insects the preparations that are made for the young are for the most part the outcome of instinct, that is, of an inborn power of doing what seems to be very wise and clever. Moreover the mother is often without the satisfaction of even seeing her offspring, for she dies before her eggs are hatched. Among birds, while instinctive behaviour continues, it is mingled with much more intelligence, and the pre-

paration of nest-making is followed up by the patience of brooding, and that again by often prolonged care, and even education. After brooding there is the labour of feeding the young, which often taxes to the utmost the energies of both parents. Miles away from the Bird-Berg, where tens of thousands of guillemots lay their eggs on the ledges of the cliffs, there is a "bank" where sand-eels abound, and it is interesting to lie in a boat and see the constant double stream of birds passing overhead, all those returning to the cliffs having a glistening fish in their mouth. We do not know which most to wonder at, the appetite of the youngsters, the unwearying industry of the parents, or the supply of sand-eels.

After the labour of feeding, comes the fine art of education, for the young bird has always a great deal to learn. Experiments have shown that the young bird is not usually rich in inborn knowledge. The chick hatched in an incubator, away from its kind, has no inborn knowledge of the meaning of its unseen mother's cluck. Even when thirsty it does not recognize water as drinkable stuff, not even when it walks through it. So innocent is it that it will stuff its crop with worms of red worsted. But it makes up for its small stock of ready-made knowledge by an extraordinarily rapid power of learning. And that is what the parent-birds work with in educating their young in the ordinary conditions of wild life.

As all Mammals except the primitive duck-moles and spiny ant-eaters bring forth their young alive,

it may be that their parental care is not quite so striking as that of birds, where the laying of eggs usually means nest-building and brooding. But we have only to think of a cat and her kittens, or of an otter and her cubs, to be assured that among Mammals also parental care may reach a high level. Indeed it is not too much to say that the secret of the success of Mammals is very largely to be looked for in the prolonged and many-sided parental care.

NUMBER VIII

THE INTERNAL ECONOMY OF THE SEA

NO one can forget the first sight of a big catch laid out for sale at one of our chief fishing ports. There are tons and even miles of fishes, which not long ago represented enormous locomotor power in the sea, and will soon be transformed into likewise enormous, though reduced, power of muscle-work and brain-work on land. The sweepings go to feed cattle and to fertilize the ground, and the total supply is in such abundance that we stand wondering at its continuance from day to day, year in year out. What happens in the vast economy of the sea? Who are the producers, the consumers, and the middlemen?

The Producers

The producers of the wealth of the sea are the chlorophyll-possessing organisms, most of which are indubitable plants, though a few incline to the animal persuasion. Of the plants there are two great groups: (*a*) the minute Algæ of the upper layers of the open sea, and (*b*) the sea-grass, the larger seaweeds, and the attendant minute plants,

abounding in the shore area in the wide sense. Though many of the seaweeds have also brown or red pigment, all have chlorophyll. And by virtue of this—we do not know how—they are able to utilize the energy of the sunlight to build up the simple constituents of air and sea-water into complex organic products which in turn form the food of animals. On this power of photosynthesis depends the whole economy of marine and of terrestrial life. It is very generally believed that the chief producers are the minute and simple Algæ of the open waters, which form in certain areas what Sir John Murray used to call "floating meadows." On the *Beagle* voyage Darwin was impressed off the coast of South America with vast tracts of water discoloured by the minute floating Algæ, the "sea-sawdust" of Captain Cook's sailors, and since the days of the *Challenger* information in regard to the minute surface plants has grown apace. They seem to be the food of many open-sea animals, such as small Crustaceans, which again are devoured by young fishes. The growth of the sea-meadows in spring is thus as important as the garment of green on the farmer's fields. Professor Herdman, of Liverpool, a leading authority on the biology of the sea, cites the calculation that a Diatom "less than the head of a pin, dividing into two at the normal rate of five times in the day, would at the end of a month form a mass of living matter a million times as big as the sun. The destruction that keeps such a rate of reproduction in check must be equally astonishing."

It should be noticed, however, that considerable evidence is accumulating in support of the view that the minute floating plants are even more important in their death than in their life. For when they are killed by changes of temperature and the like, or when they reach the end of their natural tether, they add to the valuable organic débris which remains in suspension in the water or sinks to the floor of the sea. To this accumulation of organic débris very important contributions are also made from the shore belt of seaweed and sea-grass. Indeed, recent investigations by two Danish naturalists, Petersen and Jensen, show that the organic matter of the sea-floor in the sheltered waters of fjords and bays is mainly due not to the sinking down of the minute surface creatures, but to the detritus of the sea-grass and its associates in shallow water. This is of great practical importance, since it is in man's hands to cultivate, if need be, the littoral vegetation, and thus cast bread upon the waters, to be gathered again after many days.

Sea-Meadows

In the relatively shallow Danish waters the sea-bottom consists of vast plains of sand, mud, or clay, with transitions between these ; and almost everywhere except in the deepest and calmest hollows there are scattered stones of all sizes carrying a distinctive population of their own. From the shore to a depth of two or three fathoms are the meadows of the sea-grass, with true roots and flowers and very long ribbon-like leaves, familiar as a pack-

ing and stuffing material and as a covering for Italian flasks of wine or oil. Mixed with this Zostera are the seaweeds proper, attached but without true roots, enlivening the grass-green with beautiful reds, browns, and olives. Farther out the seaweed vegetation thins, until it disappears at a depth of about twenty-five fathoms. It is a crowded vegetative area, able to support a crowded animal life ; the waving sea-grass is often as thick as the stems in a cornfield, and Professor Petersen notes that the total annual yield in Danish waters is about four times the quantity of hay produced in a year in Denmark. The Zostera is already used for fodder, for paper-making, and in other ways—but sea-grass is a difficult harvest to reap, and perhaps its greatest value is the indirect one, that it forms a basal food supply for animals on which many food fishes mostly depend. For what Professor Petersen and his colleagues have discovered is that the surface of the mud (or clay farther from shore) is covered by a thin layer of detritus of high nutritive quality, and that this is mainly produced by fragments of sea-grass and littoral seaweeds, the downward sinking surface animalcules counting for little. Examination of the stomach contents of common non-predatory animals like oysters shows that they feed very largely on the vegetable dust of the sea.

The circulation of materials is very interesting. To make a pound of cod requires 10 lb. of whelk or buckie ; to make a pound of buckie requires 10 lb. of worms ; to make a pound of worm requires 10 lb. of vegetable matter, which may be given in the

form of dust! So a pound of carnivorous fish like a cod requires 1,000 lb. of sea-grass. If there be fewer links in the House-that-Jack-built nutritive chain, the pound of flesh will be, so to speak, cheaper. Thus a pound of plaice is said to require to begin with only 100 lb. of vegetable material. But the main fact is clear that just as all flesh is "grass," so sooner or later all fish is "seaweed."

Consumers

The natural consumers of the wealth of the sea are the animals, but these are not all on the same platform. First, there are true carnivores, like most fishes, all cuttlefishes, many Gasteropods (like whelks), many crabs, most starfishes, and so on down to sea-anemones. Second, there are vegetarians, like periwinkles and limpets, on the shore, and some of the open-sea animals like the Copepod Crustaceans. Third, there is an enormous multitude depending mainly on crumbs or detritus. This classification is not, of course, to be taken too rigidly, for it will be readily understood that many a marine carnivore may also utilize animal particles —just as a Golden Eagle, with a preference for fresh grouse, does not always hold carrion in disdain. Similarly, some marine vegetarians are not too scrupulous as to the constituents of the sea-soup they enjoy. The probability is that the distinction between carnivore and vegetarian is not so important as that between animals with and animals without hard gripping and chewing mouth-parts. This, like Professor William James's division of mankind

into tough-minded and tender-minded, goes very deep. We may speak of it as the distinction between the hard-mouthed and the soft-mouthed.

Middlemen

The middlemen are Bacteria, which get involved in so many different ways in the business of life. Salt is known to be destructive of many, but it has not kept them all out of the sea, where they have more than one important rôle to play. Thus some are putrefactive, breaking down the dead bodies of animals and plants, and the excreta of animals, reducing them to carbon-dioxide, ammonia, ammoniates, and the like, which may re-enter the field of life by forming food for Algæ. Microbes of this sort are for ever making a clean thing out of an unclean. But there are others which play a subtler part, by changing the ammoniacal nitrogen into nitrites, and others which carry on this work by completing the oxidation into nitrates. And as nitrites are more available for the nutrition of plants than are ammoniacal compounds, and as nitrates are more available than nitrites, we see, as they said of old time, how well this world is governed. It is not to be forgotten, however, that there are many denitrifying bacteria which work the wrong way by reducing nitrates to nitrites, nitrites to ammonia, and ammonia to free nitrogen.

The area of comparatively shallow water round the coasts is one of the most interesting haunts of life. There are many different kinds of animal communities living there, each with a régime of

its own; the struggle for existence is intense; the life-saving adaptations and shifts for a living are endless; "passions there, laws, pursuits, tribes," as Walt Whitman said in his "World below the Brine." For it is to the region of the sea-meadows rather than to the deep sea, that most of his vivid picture applies:

> The World below the brine,
> Forests at the bottom of the sea—the branches and leaves,
> Sea-lettuce, vast lichens, strange flowers and seeds—the thick tangle, the openings, and the pink turf,
> Different colours, pale grey and green, purple, white, and gold—the play of light through the water,
> Dumb swimmers there among the rocks—coral, gluten, grass, rushes—and the aliment of the swimmers,
> Sluggish existences grazing there, suspended, or slowly crawling close to the bottom.

This and more also will be subscribed to by all who have spent a summer afternoon drifting here and there over the sea-meadows, peering into the crowded life below, enjoying the play of colour, lifting now and again a leaf of sea-grass—sometimes 6 feet long—to discover how many small creatures were browsing there, or raising more adventurously a stone from the bottom, to see sometimes a dozen different kinds of creatures living together—a little balanced world in itself. "But what an endless task have I on hand to count the sea's abundant progeny, whose fruitful seede farre passeth those on land . . . so fertile be the flouds in generation, so huge their numbers, and so numberlesse their nation."

But perhaps the most interesting feature is the circulation of matter, the flux of materials from one embodiment to another, the succession of incarnations, what Sir John Murray, who did so much to make Oceanography a science, called "the never-ending cycle." The Algæ find nourishment mingled with the water that bathes them, and, using chlorophyll to "conjure with the sunbeams," they build up organic compounds from inorganic constituents. Vegetable proteins are thus formed, and when these are eaten by animals they are raised to a still higher incarnation as animal proteins. But when the plant or animal dies the complex organic substances are broken down, through the agency of bacteria, into simple constituents once more, and some of these being utilized by plants may enter again into the circle of life. Shakespeare, with his prescience, spoke of what might happen to the dust of Cæsar, but it was only a vague vision that he can have had of the long nutritive chains, with quaint sequences like those of "The House that Jack built," which connect Diatoms and débris with fishes and man. As Professor Herdman tells us, man eats the cod, which in turn may feed on the whiting, and that on the sprat, and the sprat feeds on Copepods, which again depend on Peridinians and Diatoms. Most of the nutritive chains brings us through Copepods to sea-grass and seaweeds, to Diatoms and débris. For so the world goes round, and such are the incarnations of the sea.

NUMBER IX

FITNESSES

EVERY living creature is a bundle of fitnesses or adaptations which have been slowly wrought out in the course of ages. There has been a sifting of novelties age after age, and the result has been the survival of the fittest, which means the survival of those creatures best suited or best adapted to particular conditions of life. It is also open to the active animal to seek out situations to which its inborn peculiarities are best suited—to play the cards that heredity has put into its hands.

Illustrations of Adaptations

The structure of a long bone in a mammal is adapted to give the utmost firmness with the minimum expenditure of material; the unique pollen-basket on the hind legs of worker-bees is adapted to stow away the pollen; the colours and patterns on the wings of leaf-insects are adapted to harmonize with the foliage on which they settle; the parts of flowers are often adapted to ensure that the insect-visitors are dusted with pollen, and thus to secure cross-fertilization; the peacock is adapted to captivate the pea-hen; the mother mammal is adapted

for the prolonged ante-natal life of the young; the so-called "egg-tooth" at the end of a young bird's bill is adapted to the single operation of breaking the egg-shell—and so on throughout the whole of the animate world.

The Mole

As a particular instance of fitnesses, let us take a common animal like the mole, "the little gentleman in the velvet coat," who long ago discovered the possibility of a subterranean life for a warm-blooded animal, and disturbed the earthworms in the retreats where they had for ages enjoyed peaceful security. What a bundle of adaptations the creature is! The out-turned hand has become a powerful shovel, aided by the presence of an extra bone, the sickle, to the inner side of the thumb; the shoulder-girdle is very strong and the breast muscles are those of an athlete; the long muscular sensitive snout, which probes the way, is strengthened by a special bone near the tip; the absence of the external trumpet of the ear means a reduction of friction; the minute eyes are well hidden among the hair and thus saved from being rubbed; and there must be some special advantage, too, in the way the hairs stand out vertically like the pile on velvet. The eye is not well finished, as an instrument-maker might say—the lens in particular being only half-made, and the optic nerve far from well developed—but the mole is quite aware of the difference between light and darkness, and its eyesight is probably just as good as it needs to be.

Its habits, too, how adaptive they are!—the quick hunting close to the surface, the slow deep burrowing below the reach of the frost's fingers in winter, the nest-making below the chief mole-hill or fortress, the making of a special tunnel to the nearest water, and so on. Dr. Ritzema-Bos has verified the observation that moles make a store of earthworms for the winter months, biting their heads off so that they lie inert but not dead. If this were done in the summer months the head would be regrown and the captives would crawl away, but below a certain temperature the regrowth does not occur, and the decapitated earthworms lie imprisoned without walls.

Fly Trap

As a fine example let us take Venus's Fly Trap (*Dionœa muscipula*), a member of the Sundew family, in which there are many adaptations to catching and digesting insects. The trap of Dionæa is a much modified leaf, or part of a leaf. The blade consists of two nearly semicircular halves, united by a strong midrib; the surface is studded with reddish glands, and bears on each side three sensitive jointed hairs; on each margin there are about twenty spikes directed upwards and inwards; the stalk of the leaf is like the handle of a teaspoon with a channelled upper surface and a narrow isthmus where it joins the blade.

When an insect, attracted to the glistening moist surface, touches one of the upstanding jointed hairs, the halves of the blade begin at once to close

in upon one another, the spikes on one side fitting in between those on the other, like the teeth of a rat trap. This happens quickly, but the movement stops before the leaf is completely closed—a fact which Darwin explained ingeniously. Insects of small size, hardly worth catching, escape between the crossed teeth, and the leaf soon reopens. A larger victim, unable to get through the prison bars, touches the sensitive hairs again and induces a second and more vigorous contraction, which proves fatal. No more effective adaptation could be imagined.

Let us follow the story a step further. When the Venus Fly Trap is *tricked* into closing, it opens again in twenty-four hours. But when it shuts on a big fly it remains with the two lobes against one another for a week or more. The secreting glands are stimulated and pour out digestive juice; more and more glands join in; and the two blades bulge outwards partly with the fly and partly with the copious digestive juice. It is interesting to notice, as an instance of the kinship of all living creatures, that the closing of the Fly Trap leaf is accompanied by an electrical change similar to that associated with every muscular contraction.

Snow Shoes

One might spend a pleasant lifetime in admiring organic adaptations, and even the most matter-of-fact man must admit that many of them are fine examples of attaining effective results by very

simple means. Take, for instance, the "snow shoes" of the North American Ruffed Grouse (*Bonasa umbellata*). According to Dr. Austin Hobart Clark, these "snow shoes" develop in winter as two rows of firm plates on each side of each toe, and they increase the area of the foot by as much again. They remind one a little of the scolloped margins of the toes in a grebe. Their effect is that the bird is able to tread on the lightly-compacted snow without sinking in.

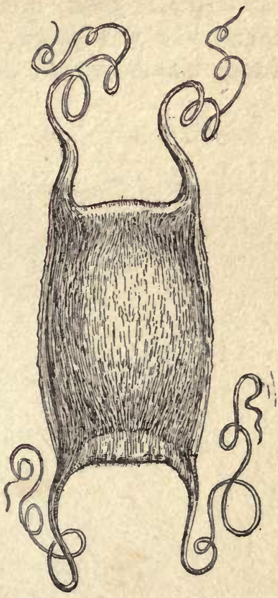
The Chick's Egg-Tooth

An adaptation that makes one think is the "egg-tooth" found at the tip of the bill in many young birds, and used to help to break a way through the imprisoning egg-shell. It is a hard thickening of horn and lime at the tip of the bill, and since it develops before the horny ensheathment of the beak, it may be a residue of a very ancient scaly armature in reptilian ancestors of birds. Be this as it may, the instrument is an effective one, and it is used only once! What happens is this: the young bird ready to be hatched changes the sideways position of its head by means of certain muscles, the trigger being pulled by a rather intricate change in the constitution. A few days after the chick is hatched the egg-tooth falls off. It has served its purpose.

The Mermaid's Purse

Every one who lives on the coast is familiar with the egg-cases of skate and dogfish, the so-called mermaid's purses. These are quadrangular sacs

with a long tendril at each of the corners; they are made of jets or fluid threads of horn which are secreted by a gland in the oviduct and coalesce into a flexible egg-case. There are no living cells in the egg-case itself; it encloses the large egg-cell laden with yolk and floating in albumen or white of egg. When the egg is liberated from the mother-fish, the tendrils writhe automatically in the water and twine round seaweed on the floor of the sea in the shallow-water area. Thus the eggs are saved from being smothered in the drifting mud, and the developing embryos within are gently rocked, and thus the better aerated, by movements in the water. But how is the embryo to escape from its closed cradle? It appears that at the time of hatching there is a secretion from the embryo which acts as a solvent on a weak seam at one end of the mermaid's purse. The end gapes, and the miniature skate or dogfish works its way out. Now it is interesting to find a parallel fitness in the far-



Mermaid's Purse, or horny egg-case of dogfish, with attaching tendrils.

separated bony fishes, where there is no egg-shell, but only a firm shell-membrane. Both in the trout and in the gold-fish the single-celled glands of the embryo's skin secrete before hatching a fluid which has a digestive action on the shell-membrane. This becomes delicate and finally almost like wet paper, readily allowing the escape of the miniature fish.

NUMBER X

THE CIRCULATION OF MATTER

WE have ceased to wonder at the circulation of the blood in our body; have we begun to wonder enough at the ceaseless circulation of matter in the system of nature? The rain falls; the springs are fed; the streams are filled and flow to the sea; the mist rises from the deep and the clouds are formed, which break again on the mountain-side. The plant captures air, water, and salts, and, with the sun's help, builds them up into the bread of life. The animal eats the plant and a new story begins. All flesh is in the long run transformed grass. The animal becomes part of another animal, and another chapter of the story begins. The silver cord of the bundle of life is loosed, and earth returns to earth. The microbes of decay break down the dead animal, and there is a return to air and water and salts. We may be sure that nothing real is ever lost, neither of matter nor of energy; we may be sure that all things flow. Like Penelope in the Greek story, Nature is continually unravelling her web and making a fresh start.

To keep a famous inland fish-pond from becoming barren, recourse was had to an interesting device. Some boxes of mud and manure were placed at the sides, yet so that none of the manure got into the water. Bacteria, the microscopic minions of all putrefaction, began to work in the mud and manure, making food for minute, but not quite so minute, animalcules called Infusorians, which multiply so rapidly that there may be a million from one in a week's time. A living cataract of these Infusorians overflowed from box to pond, and "water-fleas," which are really tiny Crustaceans about the size of pins' heads, gathered at the foot of the fall, devoured the animalcules, and multiplied exceedingly. But the water-fleas are eaten by fishes, so that the fishes were kept in good cheer. As fish-flesh is said to be good for the brain, we have traced the links of a chain connecting mud and clear thinking! What was in the mud became part and parcel of the Infusorians, which became part of the Crustaceans, which became part of the fishes, which became part of the man. And so the world goes round.

It has been shown that the more sunshine there is in the spring-time, the more mackerel there is at Billingsgate market. The mackerel feed daintily on water-fleas called Copepods in the sea, and these feed on microscopic plants and animals (Diatoms and Infusorians) which form what we might call the "stock" of the "sea-soup." But the production of these minute creatures, of which there may be millions in a few gallons, depends partly on the

composition of the sea-water, partly on the temperature and partly on the amount of sunlight. Careful records show clearly that there is a close correspondence between the number of bright sunny days and the size of the catches of mackerel. Thus, if all flesh is in the long run grass, all fish is in the long run seaweed, animalcule, and the minute fragments of seashore plants which form what we may call "sea-dust."

If we pass in imagination from the sunlit open sea to the floor of the deep sea—that strange, dark, cold, silent, monotonous world—we find that there is not really any exception, although there are no plants at all. We find that deep-sea fish feed on deep-sea fish, and fish on crustacean, and crustacean on worm, and worm on still smaller fry. But as they cannot all be living on one another, we must look for some outside source of supply. That is to be found in the ceaseless shower of more or less microscopic dying animals which sink down from the surface waters overhead (where they feed in part on microscopic plants)—down, it may be, through miles and miles of water, like snowflakes on a quiet winter day. Again we see what is meant by the circulation of matter. Again we see how the world goes round.

SUMMER

NUMBER XI

SUMMER

THE tide which begins to rise in spring reaches high-water mark in midsummer, when it often makes for itself a new shore. The buds are replaced by leafy boughs; the bud-like early flowers are succeeded by others of more liberal beauty; young things begin to come to their full strength; and Love is justified in its children. For summer is the time of greatest output and income of energy, when the fires of life not only burn brightest, but are built up for another season. It is the time of intensest effort, of richest beauty and fullest joy.

The Activity of Green Leaves

Whether we think of the green leaves in which the powers of light and life work together to build up air and water and salts into starch and sugar and proteins; or of the bees who so industriously visit the flowers and store up honey in the hive; or of the birds gathering food for their callow young; or of the haymakers busy in the heat of the day, we get the same impression of vigorous work, at the various planes of unconscious, instinctive, intelligent, and rational life.

NATURAL HISTORY STUDIES

The Colours of Flowers

The growing intensity of plant life is registered in the increasing brightness of the colours of the flowers. For although there are many bright flowers in early spring—the marsh marigold, which raises its golden cups from the ditch; the yellow celandine, which welcomes the swallow; the blue hyacinths, which make the wood-glade glorious—"the heavens upbreaking through the earth"; the laburnum, with its "dropping wells of fire"; the periwinkle and the ground-ivy, and the golden daffodils, whose dance "outdoes the sparkling waves in glee"—yet the broad fact is, that as the days grow warmer the colours grow brighter. Although we cannot without some saving clause accept the suggestion that the annual succession of floral colour corresponds to the colour scheme of the rainbow, yet it is true on the whole that red and purple, blue and violet flowers, in short, those of richer colour, become more numerous as the days lengthen.

Summer is the time of greatest industry, and greatest of all is the unconscious work of the sunlit leaves. The results of this are seen in the filling of tubers and rhizomes, corms and bulbs, and other storehouses; in the formation of next year's buds; in the making of seeds and the swelling of fruits; and again, indirectly, in the increased store of energy which is thus brought by plants within reach of animal life. The sunshine floods the meadow and sets the particles inside the green leaves a-dancing; the result of this is the making of sugars and still

more precious things. Many a meadow is almost iridescent, we can hardly see the grass for flowers, each is in a sense a fixed sunbeam; the butterflies flit from blossom to blossom, the sunbeam is in motion again.

The Business of Animal Life

That summer is the busiest time of year is plain enough among the plants, but we see this even more clearly when we watch animals. They are swayed in great part by the twin impulses of Hunger and Love. The twofold business of life is caring for self and caring for others. There is eager endeavour after individual well-being, and there is a not less careful effort which secures the welfare of the young. The former varies from a life and death struggle at the very margin of subsistence to a gay competition for luxuries; and the latter rises from necessary life-losing and instinctive sacrifice to what seems like affectionate devotion. We see this caring for self and caring for others at an instinctive level among ants, bees, wasps, and many other creatures with small brains richly endowed with ready-made cleverness. We see it mingled with intelligence in birds and mammals, in the building of nests and shelters, in the nurture of the young, and in the laying up of stores for days to come.

Summer Drowsiness

But the intensity of life, so characteristic of summer, is by no means unrelieved. Every one familiar with the country has noticed that in days

of great heat the whole aspect of Nature occasionally suggests sleepiness, especially about noon. A few clouds hang motionless in a lofty blue sky, the air is tremulous over the hot earth, the birds are all hushed in the woods, the leaves droop after extreme loss of water, the labourers have lain down in the shade of the hedge, and there is scarcely a sound save for the grasshoppers, whose interrupted chirping makes us feel the vast background of silence. Doubtless our own sleepiness exaggerates the impression; but when even the leaves sink into "sleep," few living things are likely to be wakeful. In fact, what we experience even in this country is a suggestion of the summer slumbers of mud-fishes, amphibians, and crocodiles, when the waters dry up in the pools of tropical countries. It is interesting to visit certain kinds of shore pools in the heat of the day, when there is a stillness like that of an Eastern city in siesta; and again in the morning or late afternoon, when there is all the activity of a Donnybrook Fair.

Death in Summer

There is another phenomenon that has often impressed us on a bright and breezy summer day —the sudden appearance of a dark cloud, which, though heavy with dust and rain, drifts rapidly across the sky. We can follow its shadow as it sweeps over the fields and the firth; and as it blots out the sun from us for a few long seconds, we feel a shiver of suspense. Without being sentimental we may take this cloud, no bigger than a man's

MAY-FLIES OR DAY-FLIES RISING FROM THE WATER.
The larvæ are seen below.

hand, as a symbol; it is the external counterpart of the tear which comes sometimes to all of us to blot out God's sun. Its shadow is Death's.

For in the midst of all the bustle of life, all the gaiety of summer days, he with the ever-harvesting sickle walks with swift feet. He mingles with the haymakers, and one is carried senseless off the field; he troubles the waters of the seaside town, and the ranks of the children who romped merrily on the sands are thinned; he passes among the flocks, and many need no more shepherding; he breathes among the dancing day-flies, and they sink with the setting sun. And why in the midst of life is there so much death, against which there is no standing even among the strongest? It is in part due to the fact that although the sunlight is the most powerful antagonist of the pestilence that walketh in darkness, that is to say, the disease-germs or Bacteria, the warmth and overflowing plenty of summer days favour their multiplication. It is partly because the machinery of life is by no means perfectly self-repairing, and that the creature in living is continually going into debt. And it is partly because, during an early chapter in life's history, death was made a price for giving rise to new lives, as is illustrated by so many butterflies and other animals, not to speak of flowers, which die soon after they have secured the continuance of their kind.

All Things Flow

But nothing is ever really lost in this economical world. Matter is ever circulating, in summer most actively; energy is ever changing, in summer most of all. Nothing is ever lost; all things flow. The moistened dust and the quivering air become the grass, the grass becomes the deer, the deer the huntsman, the huntsman the tiger, the tiger—with the aid of Bacteria—grass again. For so the world goes round, and, "after last, returns the first, though a wide compass round be fetched."

NUMBER XII

SUMMER FLOWERS

A FLOWER is usually made up of four different kinds of parts, arranged in circles or whorls, one within the other. Outermost are the sepals making up the calyx; they are usually firm and green; they protect the bud and steady the opened flower. Next come the petals, making up the corolla; they are usually delicate and coloured, often fragrant, and often making nectar; they thus attract insect visitors, and they are also useful in protecting the even more important parts farther in. The third whorl consists of the rod-like stamens, whose heads or anthers make the golden-yellow fertilizing dust or pollen. The innermost parts of the fourth tier are the carpels, which bear microscopic egg-cells, each of which, if fertilized, will develop into an embryo plant. Or, to put it in another way, the carpels bear *possible* seeds or ovules, which become *real* seeds when the fertilizing golden dust penetrates into them.

It was a very important discovery, in which the poet Goethe had a large share, that the flower is really made up of four tiers of transformed *leaves,*

adapted to different uses—protective and steadying leaves, protective and attractive leaves, pollen-making leaves, and seed-making leaves. The different parts all grow out of the flower-stalk as leaves do, and they often go back to the leaf-like condition—for instance, when the plant is overfed. A Canterbury bell may become a crowded green tuft, and most "double" flowers are due to stamens turning into petals. In the flower of the water-lily, the substantial green sepals pass quite gradually into white petals, and these narrow into straps, which pass into yellow stamens. In this flower and others like it we find it difficult to tell where sepals stop and petals begin, or where petals stop and stamens begin. In such ways we may convince ourselves that, though the four parts of the flower have different names and forms and uses, they have, fundamentally, a common nature, for they are all leaves, transformed in various ways and combining to fulfil the plant's chief end—that it should produce seeds which will develop into full-grown plants and bear next year's flowers.

There is a beautiful passage about the flower in one of Ruskin's letters. "You will find," he said, "that, in fact, all plants are composed of essentially two parts—the leaf and the root—one loving the light, the other darkness; one liking to be clean, the other to be dirty; one liking to grow for the most part up, the other for the most part down; and each having faculties and purposes of its own. But the pure one which loves the light has, above all things, the purpose of being married to another

leaf, and having child-leaves, and children's children of leaves, to make the earth fair for ever. And when the leaves marry they put on wedding-robes, and are more glorious than Solomon in all his glory, and they have feasts of honey, and we call them *flowers*."

In the great majority of cases the pollen is carried from one flower to another of the same kind by an insect intent on its own affairs—collecting nectar and pollen. As the dusting with pollen secures not only fertilization, but cross-fertilization, and as the latter is sometimes the only possible mode, and sometimes, at least, the most advantageous mode as far as the crop of seeds is concerned, we are not surprised to find that flowers are in many ways specially suited to attract insect-visitors of a profitable kind, and to make the most of their visits.

Let us take the simplest attraction first—that of nectar-production. The plant is a sugar-factory; the leaves make enough and to spare; there is a surplus which oozes out as "a feast of honey." But an unregulated overflow would be disadvantageous in attracting unwelcome guests; thus nectaries tend to be restricted to the flower, and to occur in useful positions in the flower. When the fit and proper visitors have come and gone, when pollination has been effected, when the season is getting on, then the nectaries close up, the feast is over, and the *fruit begins to fill.*

A second characteristic of the flower is fragrance, of which many insects are very fond. What is the origin of this incense, whose usefulness in attracting

insect-visitors is so obvious? The answer is that the fragrant substances are waste-products or by-products of the vital processes that go on in the plant.

A third attraction of flowers is their colour. The pigments that produce most of the colours except white have various meanings in the life of the plant. Some are unimportant by-products, of little or no direct internal use after they are formed; others are very important by-products, of much direct internal use. Some seem to belong to the series of reserve-products, but most seem to be waste-products—the ashes of the vital fires. In some flowers the bright colouring means that a part is not getting sufficient food; in others, too rapid life; in some, too little moisture; in others, too much light; but in the majority it means *beauty for ashes.*

It is difficult to find out to what extent the insect-visitors like colour as such, or how far they simply connect certain colours with previous successes in collecting nectar and pollen, Another difficulty is to distinguish colour from brightness of surface. But after making some allowances it seems still good science to say that the colours of flowers attract certain kinds of insect-visitors.

We must not leave the summer flowers without at least admiring the gorgeous pageant of Flora's Feast. The tide which sets in with a rush in spring reaches its high-water mark in midsummer. Play gives place to industry, and the frolics of youth to the strenuousness of full strength. The buds

are replaced by hard-working leafy boughs with intense activity, especially in the sunlight. The bud-like, more primitive, early flowers are replaced by more generous floral magnificence.

NUMBER XIII

FRANKINCENSE AND MYRRH

WHEN we come in the sunshine upon a patch of mown grass with a good proportion of Sweet Vernal, we feel a great satisfaction. For the moment all is right with the world. But why it should be so, it is difficult to tell. The fragrances in plants are usually due to oils and resins, which are made by the plant in the course of its living. Should one of these stuffs with a strong smell turn out to be very attractive to welcome insect-visitors, such as bees, or very repellent to voracious enemies, such as snails, then it will have value for the plant, and it will tend to grow in strength from generation to generation till it is strong enough.

When we pass the open-air fire where the woodman is burning rubbish, we often feel the pleasant fragrance. The by-products and waste-products of the woody wreck are carried from the fire in the hot air. So, as we sniff the perfumed air in which quintillions of aromatic particles are hurrying past us, here from gorse and hawthorn, there from woodruff and sweet vernal grass, we are probably smelling

the by-products and waste-products of the plants' living fires, for all living is a slow burning away.

What a medley of odours, whiffs of brier rose and lady's bedstraw, honeyed clover and soporific myrrh, but they are all different. All flesh is not the same flesh, and each flower's fragrance is its own and no other's. Some five hundred different fragrances have been distinguished, one kind in hawthorn, another in mignonette and violets, another in geranium and rose, another in orange and lavender, and so on. Besides the differences in chemical composition and in scent there are other individual peculiarities, for some plants have fragrant leaves, while in others the incense is made only by the petals; some, like the grass of Parnassus, are sweet-scented only in the sunshine, while others, like the evening campion, wait for the night. The sickening smell of corn-spurrey is especially strong after a summer shower.

The making of strongly smelling stuffs is characteristic of flowering plants, but by no means confined to them; it is well known, for instance, in the males of many butterflies and moths. Peculiarly shaped scales on the wings, or tufts of hairs on other parts of the body, produce an aroma which pleases the female insects. Some of the scents produced by male butterflies and moths are pleasant to us, resembling musk, mint, vanilla, honey, and the like; others suggest mice and bats. It is interesting to notice that in some cases, though the aromatic scales are abundant, we cannot smell anything, which probably means that these particu-

lar odours lie beyond the range of our sense of smell, just as many rays of light lie beyond our range of vision. It may be recalled that the poison of toads inflames the lining of our nostrils if we sniff it, yet there is no smell. It is certain that the world is full of scents, as of sounds, to which, happily or unhappily, our senses are not attuned. There is proof of a very keen sense of smell in many insects, such as hive-bees, and its value to flower-visitors is great.

Smelling stuffs are formed in many insects besides moths and butterflies, as every one knows in the case of cockroaches and bugs, and it is possible that they have to do with waste-products, just as the white and yellow colour of some butterflies is a literal beauty for ashes. The odours are of use in helping creatures of the same kind to recognize one another quickly. In certain cases they may be protective: thus shrews are in some measure saved from cats by a smell-making gland which runs along the side of their body. In the homing of many ants minute particles with an odour serve as guide-posts, and the accuracy with which a dog tracks his master's footsteps is one of the marvels of everyday life.

The sense of smell is nearest that of taste, and the two are almost the same in some of the fishes. In smelling we are affected by minute particles which are dissolved on the moist surface of the lining of our nostrils; in tasting we are affected by substances similarly dissolved on our tongue. In old days the sense of smell meant more to man than

it does now; it is apt to be dulled by the strong artificial odours around us. But it will be a great pity if we let it go, for the frankincense of flowers is certainly part of the charm of summer days.

NUMBER XIV

SUMMER INDUSTRIES

SUMMER is the time for a study of the industries of living creatures. These industries have to do with getting hold of things and powers, changing them from one form to another, storing them, and distributing them. The chief aim of the industries is to keep life agoing and to make it more successful and satisfying. Their external result is always a product, or some change in the form, position, or usefulness of a product. Thus war is not an industry, but weaving is ; eating is not an industry, but hunting is.

The industries of living creatures are not all on the same level as regards the help that they require from the mind. Indeed we may arrange them on a staircase of five steps ; or, better still, on a long inclined plane marked by five more or less clear divisions.

The Inclined Plane of Activities

Lowest are those activities which go on automatically, without any nervous system. Such are the most important changes of matter and energy that we know of in the whole world, namely, those that

go on in green leaves, when, with the help of the sunlight shining through a screen of chlorophyll, they form complex stuffs like the starch of the potato and the gluten of wheat out of the simple elements of earth, water and air.

On a second level are "reflex actions," which do not require guidance or control, but depend on inborn linkages of nerve-cells and muscle-cells, which work when some outside cause pulls the trigger, so to speak, or releases the spring. We touch a hot iron, and without, in the strict sense, willing it, we draw our finger away. A stimulus has travelled up a sensory nerve to the spinal cord, and a stimulus has passed down a motor nerve to the muscles, commanding them to effective action. This is a reflex action of a simple kind, but there are elaborate activities and even parts of industries which appear to be compound reflexes.

On a third level are those activities which are called instinctive. By which is meant that they are performed in virtue of an inherited capacity; that they require no learning or experience, though they are usually improved by both; that they are shared alike by all members of the species, or, at least, by those of the same sex. Most animal industries must be included here, though there is sometimes a spice of intelligence intermingled in their performance. The spinning of spiders, the comb-building of bees, the paper-making of wasps, the agricultural industries of ants, and so on, seem to be, for the most part at least, instinctive. The animals are, so to speak, hereditarily wound

up to do what they do. They are born with a ready-made power of doing certain things well.

On a fourth level are intelligent activities, which include some animal activities and parts of others. Here a higher note is struck. The animal is not only conscious, but controlling and contriving. It adapts old means to new ends, it profits by experience, it puts two and two together in a simple way at least. Thus when a spider departs from its usual routine to make a web adapted to entirely novel circumstances—for instance, to the wind on the seashore, when a bee mends its comb in a fashion that we cannot help calling ingenious, when a monkey works a screwdriver, when an elephant helps to make a railway, and so on, we must allow at least a spice of intelligence, and often much more.

But there is a higher level still—that of rational activity; and, so far as we know, we have this field all to ourselves. By rational, as distinguished from intelligent, is meant, that the activities require not only putting two and two together and profiting by experience, but a preliminary experimenting inside our heads with general ideas, like those of mathematics. The Forth Bridge was built intelligently, but it was planned rationally.

Kinds of Industry

In illustrating animal industries we may group those concerned with food-getting under the convenient heads of the great human occupations of hunting, fishing, shepherding, and farming.

Of hunting there are many kinds. Lurking is

illustrated by the crocodile at the water's edge, by the snake in the grass, by the octopus among the rocks ready to grapple a dreamy fish, by the young ant-lion who digs in the sand a pitfall for unwary insects, and by a thousand more.

Others prowl about in search of their prey—the cats large and small treading noiselessly with claws of steel under their velvet gloves, the snakes gliding swiftly in the jungle like Kipling's famous Kaa, the foxes alone, the wolves in packs, the bats and owls and a hundred others by night, the eagles and swifts and a thousand others by day, the monkeys seeking out the orchards, the otter the trout-pools, the walrus the mussel-beds, some with wondrous swiftness like the weasel after the rabbit, others with great leisureliness like snails on the hunt for mushrooms. There is no end to the variety of ways and means.

Some of the details of device are full of interest. The thrush breaks the snails' shells against a stone, making heaps of the remains, reminding us of the "kitchen-middens" which still bear witness to the meals of prehistoric man; rooks sometimes let freshwater mussels drop from a height on to the gravel, and it was thus that a Greek eagle killed the poet Æschylus by letting a tortoise drop on his bald head, which glistened like a white stone; the oyster-catcher knocks the limpet off the rock with a dexterous stroke of its strong bill; the grey shrike stakes its victims on thorns.

Of hunting by means of snares the best illustrations are afforded by spiders, which show all levels from

tangles of silk lines among the herbage to finely finished webs. There is an interesting South American spider which makes its web in the early hours, but rolls it up and decamps with it after the sun rises. Penelope-like it destroys its webs daily, but not without result to man as well as to itself, for it catches the minute winged males of the destructive Coccus insects. After retiring under the shade of a leaf, the spider investigates the insects in its rolled-up net, and spends the hot hours in digesting their juices.

PERIPATUS.

Quite unique is the method of capture seen in the case of Peripatus, an animal of ancient pedigree and very wide geographical distribution. It hides during the day and becomes active in the evening. It captures small insects by squirting jets of slime on them from two papillæ in its mouth.

Fishing

Fishing is only a variety of hunting, but it may be considered separately. Typical of the patient angler, the heron stands by the pool-side—still as a statue, but able to strike with almost electric suddenness, or to fly away with dignity if we disturb his fishing. But perhaps we should have given first place to the angler or fishing-frog—a fish that

fishes. He is very inconspicuous as he lies squat on the sand in shallow water, and he is sometimes half covered with sand. Three elastic rods, one of them very strong, rise from the middle line of his back, and at the end of each there dangles a shred of skin like bait at the end of a fishing-line. These living fishing-rods are hinged at the base, so that they can be lowered or raised, and they are obviously transformed fin-rays. It is supposed by many that the shreds of skin, dangling loosely in the water, suggest worms to curious little fishes ; it is supposed, at least, that they serve to attract attention. What is certain is that many small fishes are engulfed in the angler's wide gape, and gripped firmly by backward-bending hinged teeth which make entrance easy but exit difficult.

The tales of the fishing exploits of animals, like stories of fishing at a higher level, are often a little difficult to believe. One of the deep-sea fishes with a huge gape has been known to swallow a fish larger than itself ; a big spider has been known to land a small fish ; the archer fish makes its living by shooting drops of water on passing insects. But perhaps more instructive than such oddities is the habit pelicans have of fishing in company, and wading shorewards in a deadly crescent, prophetic of the seine-net. In his book on "Mutual Aid" Prince Kropotkin described their co-operative industry : "They always go fishing in numerous bands, and after having chosen an appropriate bay, they form a wide half-circle in face of the shore, and narrow it by paddling towards the shore,

catching all fish that happen to be enclosed in the circle. On narrow rivers and canals they even divide into two parties, each of which draws up in a half-circle, and both paddle to meet each other, just as if two parties of men, dragging two long nets, should advance to capture all fish taken between the nets when both parties come to meet. As the night comes they fly to their resting-places—always the same for each flock—and no one has ever seen them fighting for the possession of either the bay or the resting-place. In South America they gather in flocks of from forty to fifty thousand individuals; some enjoy sleep while the others keep watch, and others again go fishing."

Shepherding

Of shepherding, the only clear illustrations are to be found among ants, some of which keep aphides or green-flies, and others scale-insects. This extraordinary habit was well known to Linnæus, who called the aphides the ants' cows (*vaccæ formicarum*), and it has received considerable attention from many observers. Perhaps it began in the simple fact that the ants and the aphides frequented the same trees, dining, as it were, at the same bountiful table. Then it was discovered that the aphides would yield up some of their "honey-dew" when licked or tickled, and the ants traded on this. Gradually, perhaps, the ants began to take some charge of their cattle, even building "aerial stables" for them on the branches. The ants are accustomed to put their pupæ out to be

sunned, and to carry them back again when it rains; perhaps this habit led on to what at first sight is so startling, that the ants take aphides down into their underground nests, and take care both of them and of their young.

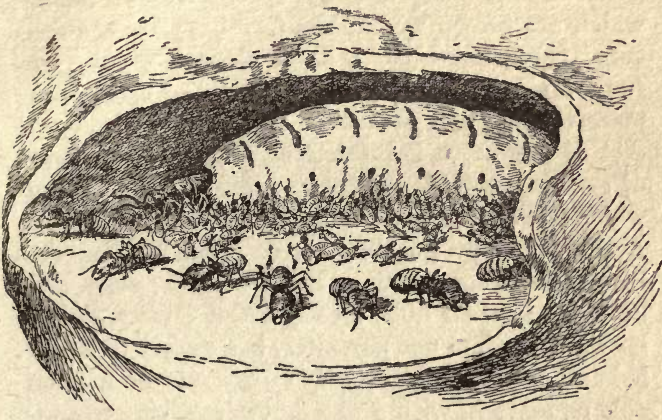
How quaint is the case of a mosquito which cannot bite, but has learned to milk ants. It has somehow discovered the profitableness of the old advice—"Go to the ant, thou sluggard." The mosquito frequents certain trees in Java, on which the ants in question go to and fro. It hails a passing ant and strokes the head with quick movements of its forelegs and antennæ, probably tickling, perhaps massaging, the ant. In any case, the ant emits a drop of juice, which the mosquito sucks up. Then the ant goes on its way.

Agricultural Operations

Agricultural industries are again illustrated among the ants. The harvesting of grain, believed in from ancient days, has been verified by modern naturalists. In his *Agricultural Ant of Texas*, M'Cook gave an account of the abundant red-bearded ant, which weeds out circular discs in open ground, tolerating only the needle-grass, whose seeds are gathered and stored along with others in underground granaries. "Not a plant is allowed to intrude upon the formicary bounds; and, although often seen, it was an interesting sight, after pushing through the high weeds, to come upon one of these nests, and observe the tall, tough vegetation standing in a wellnigh perfect circle around the edge of the

clearing. The weeds had grown up as closely as they dared, and were held back from the forbidden grounds by the insects, whose energy and skill could easily limit their bounds."

Of a leaf-cutting and seed-gathering ant of Dalmatia we are told that it collects seeds and allows them to begin to sprout before taking any further



TERMITES OR WHITE ANTS.

The "royal chamber" of a termitary, containing the queen, as long as a first finger, surrounded by worker-termites and soldier-termites with big jaws.

step. This seems contradictory to what is reported of other ants that they treat the seeds in such a way —by nibbling them or injecting formic acid—that they cannot sprout. In the case of the Dalmatian ant the collected seeds have hard coats, and the beginning of sprouting may serve to burst them. When this has been done the ants expose the seeds,

which then stop sprouting. When the seeds are thoroughly dry and dead, they are taken back again to the nest and chewed into a dough. This is baked in the sun into minute biscuits, which are stored. Here is an industry that comes very near to cooking.

One of the most extraordinary habits of the termites or white ants, so abundant in warm countries, is that about thirty different species feed on moulds which are grown within the termitary on specially constructed maze-like beds of chewed wood. The fungi are believed to afford a supply of nitrogenous material which is scarce in the termite's ordinary diet of wood. It is interesting that a similar habit of growing moulds occurs in some of the true ants which belong to quite a different order of insects. And a similarly puzzling convergence is illustrated by the fact that termites, like true ants, often have boarders in their hills, mostly small beetles, neither hostile intruders nor parasites, but guests which are fed and cared for apparently on account of a palatable exudation, with a pleasant narcotizing effect on the termites !

Making Shelters

After the industry of securing food, which has so many forms, may be ranked that of making shelters, including clothes. Although Carlyle and others have pointed out that man is the only clothed animal, the point is debatable. It is difficult not to regard as clothing the cocoon of a silk-worm or the case of a caddis-fly, and there are crabs which fix seaweeds on their backs, or cut off

the tunic of a sea-squirt and use it as a cloak.

Of making shelters there is great abundance of illustration. They are often hollowed out in earth and wood, and vary from rough burrows like a rabbit's, to a beautifully finished structure like the tube of the female trap-door spider, with its hinged door and its side-room with a curtain over the entrance. Or they may be made of light materials, woven or sewn or somehow fastened together, one of the most striking types being the decorated bower of the bower-bird, since it is a house rather than a cradle, as most nests are. Or they may be genuine buildings of clay or other material. At one end we may place the substantial termitary, sometimes ten feet high and strong enough for a man to stand on; at the other end the dainty nest of the wasp, almost as light as a feather.

Let us take one instance of the manner of working—the behaviour of the tailor-ants, common in hot countries. They draw leaves together to make a shelter, and sew them with silk. But as they have no silk of their own they use their silk-secreting larvæ to furnish the thread. They sometimes find it difficult to bring two rather distant leaves close enough together to be sewn, and then five or six will form a living chain to bridge the gap. The waist of A is gripped in the jaws of B, who is in turn gripped by C, and so on—a literally living chain, a notable gymnastic feat. Several chains will work together for hours on end trying to draw two leaves close together.

We see that there are many kinds of animal

industries, and that some play an important part in keeping the world going. They are usually very effective in their performance and beautiful in their results. Their end is often not self-preservation but the well-being of the offspring, whom the toilers, in not a few cases, never survive to see.

NUMBER XV

GUESTS AND SLAVES OF ANTS

A GREAT number of cases are now known where small beetles or other insects live on friendly terms with ants. One of the most extraordinary cases is that of certain little crickets (called *Myrmecophila*), which have become guests of ants. Particular guests are wont to be associated with particular hosts; thus one of the little crickets is usually found in the nests of the black ant, and, in suitable localities, of the red ant. The reason for the picking and choosing of a host is probably to be found in some suitability in the relative size of host and guest. The little crickets get shelter and food; they lick their hosts, who give up some of their food; they plunder the worker-ants returning to the nest with spoils; they steal from the newly-fed young ants; they insist on having a share when the ants are eating; and, finally, they sometimes demand food from the ants, raising their forelegs in a peculiar fashion. In this movement and in that of their feelers there seems to be something like an imitation of the ants' movements, but in other ways their movements are very different from those of their hosts. Why the ants tolerate them, who can tell?

It is easy to understand the crickets being content, but why the ants submit to their presence is a mystery. If they thought of it, they could soon kill them off, for ants can combine and they can bite or sting, but they do not think of it. Perhaps we make a mistake here in using words like "guest" and "host"; perhaps the little crickets do not matter much as long as they are not too numerous. Perhaps, and perhaps, and perhaps.

In quite a number of ants' nests, there are guest beetles or pet beetles, which the ants take care of and evidently regard with pleasure. They are often fragrant and they do no harm. They may be compared to cats in our dwellings—genuine pets.

Another remarkable case is the occurrence of the caterpillars of a small moth in the nests of a New Zealand white ant or termite. The caterpillars depend upon the material of the nest for their food, and they may be seen moving along, at regular intervals as if in a procession, each escorted by a few soldier and worker termites. It appears that the caterpillars exude a strong odour which is attractive to the termites. Just as man may have flowers in a room for the sake of their perfume, so the white ants have caterpillars.

Like some true ants, so some of the white ants have as guests little beetles which give off a soothing fragrance, especially when they are caressed. This perfume seems to please the termites, just as tobacco pleases many a man.

Besides guests who are, so to speak, favourably regarded by their hosts, whether these be white

ants or true ants, there are other inmates which may be compared to mice in our houses. They do harm, but it is difficult to get rid of them.

On a different platform are the green flies or aphides, which some kinds of ants treat as domestic animals, milking them to get their overflowing sweet food. The ants herd these aphides, and they sometimes take them into underground stables when winter comes.

Slave-Keeping

If slave-keeping among ants occurred once or twice, we might think it was some strange freakishness among the little people, but there are many instances and many stages of the "institution."

A fertilized queen of the red ant, *Formica sanguinea*, may fall after her nuptial flight into a nest of black ants, *Formica fusca*, where there is no queen. She is received and fed, and the eggs which she lays are tended. A mixed colony arises, with the reds as masters and the blacks as slaves, the former being more active in external operations and the latter in the discharge of domestic duties. As the blacks do not multiply, the reds make sallies and bring back pupæ from neighbouring nests of blacks. Those that are not eaten grow up to slavery. Sometimes, however, the slaves gradually decrease in number, and the mixed colony becomes a pure red colony. In this case, therefore, the slave-keeping need not be more than temporary.

In the Amazon ants (e.g. *Polyergus rufescens* in Europe and *P. lucidus* in America) the "institution

of slavery" has developed, and there are probably no slaveless colonies. A fertilized queen is accepted by some queenless colony of black ants or the like; her offspring are tended and become dominant; and the number of slaves is sustained or increased by slave-capturing raids. Forel calculated that a single colony may capture in the course of one summer as many as forty thousand larvæ and pupæ of slaves—who grow up to do everything for their masters, just as if these were their own kith and kin. For the Amazons can do nothing but raid; their mandibles have become sabres quite unsuited for humble toil; they cannot dig, but to beg they are not ashamed. Without their slaves they starve to death in two or three days.

In a sense, then, the tables have been turned, and the slaves are the masters. The Amazons fight and multiply, but the slaves "determine the character of the nest, plan and conduct migrations, carrying the Amazons from place to place, the latter subject to no impulse of their own. . . . In America this once widely distributed species is on the road to extinction." It is plain that it is a very dangerous thing to become quite dependent on other people.

NUMBER XVI

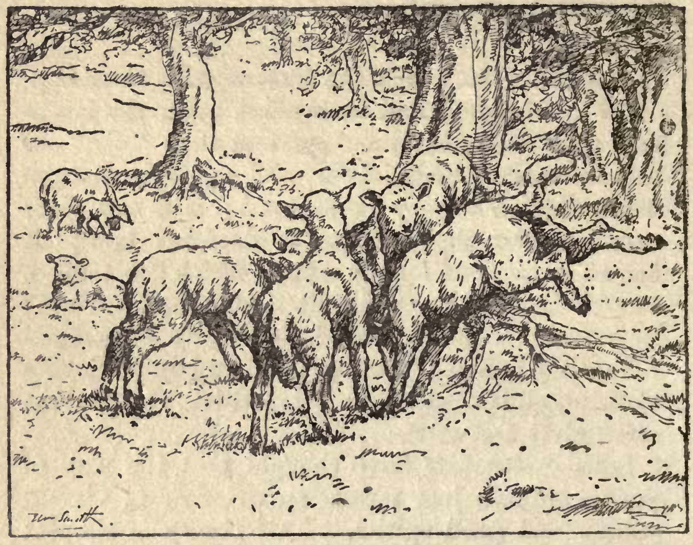
THE PLAY OF ANIMALS

WHEN we watch the kittens with their ball, the dogs and their sham hunt, the lambs and their races, the monkeys and their "tig," we see animals at play. It is well marked off from work, though it may be as hard; it is not mere exercise, though, perhaps, it exercises best; it has no serious end for the sake of which it is played, though it may be, while it lasts, most serious; it is not necessarily social, for many an animal (like many a man) seems to be quite happy playing alone; and it need not be competitive, though that often gives zest to it.

Some naturalists have thought that the play of young animals just means an overflow of vigour, energy and good spirits. This theory is simple; but it is too simple, and it breaks down. No doubt the young creature is an overflowing well of energy; but even the tired animal or child will turn in a moment from fatigue to play. It has also been pointed out that imitation counts for a great deal in animal play. The youngsters mimic in play what they see their seniors doing in earnest. There is truth in this, but it cannot be the whole truth.

A kitten taken very early from the mother will play with zest, though it has no model to copy.

According to another view there are inborn play-instincts, characteristic in form for different animals. The trigger may be pulled by overflowing energy, and imitation may have some influence,



LAMBS AT PLAY.

but the love of play and the kind of play are born in the creature.

Play is justified in the business of life in at least two ways; firstly, because it is the apprenticeship to future work, the training for serious efforts, the rehearsal before the real performance; and, secondly, because it gives an opportunity for sharpen-

ing wits and for learning before mistakes are too costly.

But we may go a step further. Play is more than the apprenticeship to future life and work. It is more than an opportunity for learning the alphabet of life. It is one of the few opportunities which allow new experiments to be made without too vigorous criticism. In the real business of life all sorts of novelties are very apt to be nipped in the bud. Play is Nature's device for allowing elbow-room for "new departures" which may form part of the raw materials of progress.

There seem to be two original forms of animal play—the play of movement, and the play of experiment. Let us, first of all, consider play of movement.

Play of Movement

"Most young things," Hamerton says, "appear to be reservoirs of pent-up natural energy that finds vent in irrepressible gambols." Insects gambol in the air, birds among the boughs, dolphins in the waves, and so on, endlessly—each in its own way. There is no use in it, except that the nerves and muscles are trained for future work. The heart beats more quickly, the breathing is more rapid, the surface blood-vessels become larger, and the player enjoys that happiness which is always the reward of wholesome activity.

Perhaps part of the meaning of this simplest form of play is to be found in the connection between pleasant emotion and muscular movements. Such

exuberance of good spirits had the simple wood-chopper portrayed in Thoreau's *Walden*, that when a thing amused him, "he sometimes tumbled down and rolled on the ground with laughter." Perhaps we have here an expression of primitive playfulness.

When we see beautiful sights, or hear fine sounds, or the like, pleasant messages have, of course, travelled by our nerves into our brains. But they do not, so to speak, stop there. They set agoing other messages, which travel out to the heart, which beats differently; to the larynx, which vibrates; to the lungs even, and to other parts. In short, internal muscular movements occur. As the result of these, a third set of messages travel in again to the brain; and when the circle is completed, *we are pleased.* Perhaps in this way one gets nearer an understanding of certain gambols and of the vocal play—the song—of birds, in which internal movements are associated with strong emotions. In any case, there is reason to believe in a deep and subtle connection between emotion and motion. Literally, Wordsworth's heart leaped up when he beheld a rainbow in the sky, and filled with pleasure as he watched the dancing daffodils.

The play-nature of animal movements is clearest when there is something unusual about them. Thus Alix relates that on one occasion, when botanizing on the Alps, his dog ceased to follow him on the gradual path, and seemed deliberately to choose a long slope of frozen snow. There he lay down on his back, folded his legs, and slid down like a toboggan. At the foot he rose quietly, looked up to

his astonished master, and wagged his tail. Alix imagined that his dog had thought out the short-cut; it is much more likely that it was simply play—done for fun.

Play of Experiment

Let us pass to the other original expression of the play-instinct, what we may call experimenting —when animals test things, often pulling them to pieces; or test themselves, often performing interesting feats; or test their neighbours, finding out how they will answer back. For the endless task of finding out about the world has its play-form—which is one of the roots of science.

Speaking of his young goats, Mr. Hamerton says: "If there is a basket in the place which will hold one of them, and no more, the others will watch him with great interest, and as soon as he jumps out (which he is never very long in doing) the others inevitably jump in and out again by turns. A game of this kind will last till one of the kids has a new suggestion to make." One day it was the fashion among the kids to carry a little sprig of green between the lips; another day they tried to upset the artist by getting under his seat; from that they passed to experimenting with the big dog, till "he could stand it no longer and rushed out of the place, not trusting himself to refrain from using his mighty jaws, which would have crushed a kid's head like a nutshell."

In regard to her Capuchin monkey, Miss Romanes wrote: "He is very fond of upsetting things,

but he always takes great care that they do not fall upon himself. Thus, he will pull a chair towards him till it is almost overbalanced; then he intently fixes his eyes on the top bar of the back, and, as he sees it coming over his way, darts from underneath, and watches the fall with great delight; and similarly with heavier things. There is a washhand-stand, for example, which he has upset several times, and always without hurting himself. One day he played for a long time with a hearth-brush, learning to unscrew the handle and, what was much more difficult, putting it together again. When he had become by practice tolerably perfect in screwing and unscrewing, he gave it up and took to some other amusement."

Sham Hunt and Sham Fight

Passing from gambol and experiment to somewhat subtler forms of play, we find that a number of animal games may be summed up under the title "sham hunt." Into this there seems to enter a certain amount of "make-believe." The booty may be real, as when the cat plays with the mouse, or both the booty and the chase may be fictitious. The sham booty may be living, as when the dog plays with a beetle; or, more commonly, not living, as when the kitten plays with a ball of twine.

Another type of play is the sham fight, which we see so often between puppies or kittens. It has been described among lions, tigers, hyænas, wolves, foxes, bears, and other carnivores; among lambs, kids, calves, foals, and other ungulates; it is also

very common among birds. Care must be taken to distinguish sham fights from real fights, and it may be admitted that among animals, just as among boys, what begins in fun may readily pass into deadly earnest. In a vivid description of the behaviour of two young gluttons, Brehm says that nothing could be more playful, they are almost never at rest for a minute, they fight in fun all day, but every now and then the note of earnest is struck.

The sham fight is one of a large group of social plays, of which the characteristic note is rivalry —rivalry, however, which has no serious reference to any necessity of life. There is no doubt that competition gives zest to animal games as well as to those of man. It seems to be a pleasure to the animal as to us "*to be a cause*"; it is a greater pleasure to be a better "cause" than some one else. We see this in the races among lambs and kids, wild horses and asses; in the various forms of "tig" and "follow my leader" in monkeys; and in other rival exhibitions of agility. Perhaps some forms of dance and song should be included here.

To sum up: There are many play-instincts among animals; they have been wrought out in the course of ages, partly as safety-valves for overflowing energy and spirits, partly because movements and feelings are naturally linked together, partly as opportunities for trying novelties before too stern criticism begins, but mainly as periods for educating powers which are important in after-life. Animals, Groos says, do not simply play because

they are young; they continue young in order that they may play.

In short, play is so widespread because it is *the young form of work.* The animals who played best when young, worked best, lived best, perhaps loved best when they grew up, and thus through the long ages the play-instinct has been fostered. It is interesting, also, to notice that the animals which man has succeeded in domesticating are mostly playing animals.

Play is thus a rehearsal without responsibilities, a preliminary canter before the real race, a sham fight before the real battle, a joyous apprenticeship to the business of life. Thus our study of animals playing in the summer sunshine gives a deeper meaning to the familiar saying, "All work and no play makes Jack a dull boy." May we not twist an old precept a little, and say, "Let us play while we can, so that we may work well when we will"?

NUMBER XVII

EXAMPLES OF INSTINCT

WHEN we pass in the Animal Kingdom from brainless types, like polyps and star-fishes, to creatures of higher degree, like crabs and ants and spiders, we find ourselves in a new world. There are still many instances of the old, almost automatic "answers-back," illustrated when a sea-anemone's tentacles close on the food, but there is a new kind of behaviour much more complicated, which is called *instinctive*.

When a shore-crab is carried over the beach and then laid down, it makes for the sea in its own peculiar sideways fashion. Light and wind and slope seem to have no effect; it makes for the moisture of the sea. This is probably the outcome of an engrained "answer-back" to certain messages from the outside world, but it is on the border-line of instinct.

When a worker-bee, coming out of the hive for the first time, flies to a flower which it has never seen before, and tackles it deftly, collecting pollen and nectar, it illustrates instinctive behaviour. We say that it does its work "as to the manner born";

and it is characteristic of instinctive capacity that it is hereditarily entailed.

An unhatched lapwing may be heard saying "pee-wit" from within the egg. This is its distinctive call-note, and its utterance appears to be instinctive—quite independent of instruction or imitation. Chicks reared in an incubator have the usual vocabulary. This, again, is characteristic of instinctive behaviour, that it does not require education or example or practice, though it may be improved thereby. Instinctive behaviour is a complicated answer-back that has a high degree of perfection from the very first.

The mother Sphex-wasp stocks each of the cells in her nest with three or four paralysed crickets. On the under side of one of these (turned on its back) she fixes an egg, out of which in three or four days a delicate worm-like larva is hatched. This tiny creature bores a hole through the cricket's armour, makes its way into the paralysed body, and proceeds to devour the tissues. In a week or so, having exhausted the food supply, it goes out by the aperture by which it entered, and proceeds to enjoy another cricket. In about twelve days it has eaten all its larder. Its behaviour is strikingly instinctive.

The way in which some new-born mammals immediately proceed to suck their mother illustrates an instinctive endowment. Each little pig the moment that he is born hurries over his mother's hind legs, and, in the second second of his outdoor life, has a teat in his mouth. Newly-born pigs also show instinctive

knowledge of the meaning of the sow's grunting. Spalding put a young pig into a bag the moment it was born, kept it in the dark for seven hours, and placed it near the sty, ten feet from where the sow lay concealed.

"The pig soon recognized the low grunting of its mother, went along outside the sty, struggling to get under or over the lower bar. At the end of five minutes it succeeded in forcing itself through under the bar at one of the few places where that was possible. No sooner in, than it went without a pause into the pig-house to its mother, and was at once like the others in its behaviour."

A blindfolded youngster found its mother almost as well as one with its eyes free. After two days' blindfolding it required only ten minutes' practice to make it "scarcely distinguishable from one that had had sight all along."

In the strict sense, birds do not *learn* to fly, though their inborn capacity of flying is improved by exercise. Spalding put five unfledged swallows in a small box with a wire front, and hung it near the nest. The parents fed the offspring through the wires, and the young birds throve as usual, though one was found dead just as it became fully fledged. The others were set free one after another. Two of them were perceptibly wavering and unsteady, and two were more effective from the first. But even the less endowed flew ninety yards right away, and none of them knocked against anything. In a subsequent experiment one of the newly-fledged, newly-liberated birds performed almost at once

magnificent evolutions over the beech trees. All this was performance without practice, for the swallows had not been able even to extend their wings in their narrow prison.

In the familiar case of the spider's web, there is no evidence that the spinner improves by practice. The first web made by the young spider has all the parts seen in the web made by the adult. As garden spiders grow older the thread becomes thicker and the web larger; there are a few more radial rays and a few more loops in the spiral, but these differences are connected with the increased weight of the spider and the increased size of the spinning organs. There is more material to work with, and the web is a little more substantial, but there is no real change, nor need for any.

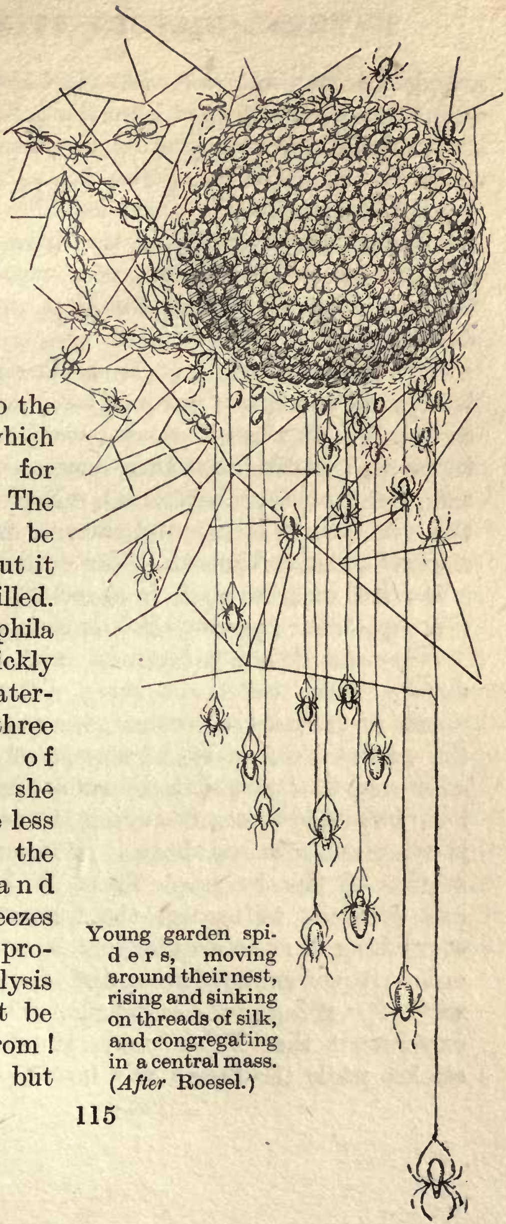
We shall take two or three instances of instinct from the works of the great entomologist, Henri Fabre, whom Darwin called "that inimitable observer."

Picture the ringed Calicurgus wasp, which first stings its captured spider near the mouth, thereby paralysing the poison claws, and then, safe from being bitten, drives in its poison needle with perfect precision at the thinnest part of the spider's armour between the fourth pair of legs.

Looking in another direction, what can we say of the mother of the Halictus bee family, who, after prolonged maternal labours, becomes in her old age the portress of the establishment, shutting the door with her bald head when intrusive strangers appear, opening it, by drawing aside, when any

member of the household arrives on the scene?

The solitary digger wasp, Ammophila, is wont to drag caterpillars to the living larder which she collects for her young. The victim must be made inert, but it must not be killed. The Ammophila first and quickly stings the caterpillar in the three nerve-centres of the thorax; she does the same less hurriedly for the abdomen; and then she squeezes in the head, producing a paralysis which cannot be recovered from! This ghastly but



Young garden spiders, moving around their nest, rising and sinking on threads of silk, and congregating in a central mass. (*After* Roesel.)

wonderful manifestation of instinct requires no apprenticeship, it is perfect from the first, it expresses an irresistible inborn impulsion, at once untaught and unteachable. The insect's achievements are due to "inborn inspirations." They look like intelligence; but disturb the routine, and the difference becomes at once apparent. To instinct everything within the routine is easy; but the least step outside is difficult.

It is many years since Fabre described the behaviour of the Sphex wasp in stocking a larder for its young. It makes burrows, each consisting of a horizontal porch, a sloping main shaft, and off this three or four horizontal cells. In each cell the wasp places an egg and three or four paralysed crickets or related insects. Each cell is closed when it is filled, and the shaft is closed when the storing is completed. Another shaft is then sunk.

When the Sphex catches its cricket it stings it, usually three times, in three different strategic points in the nervous system, the result being that the cricket is incapable of movement, but remains alive until the larvæ of the Sphex are ready to devour it. When the Sphex has stung the cricket, it grips it by an antenna and drags it or flies with it to the mouth of the burrow. There it lays it down, and proceeds to inspect the burrow to see that everything is as it should be. If everything is in order, it comes up again, and drags the cricket with it, going in backwards. The interesting experiment that Fabre made was to remove the cricket while the Sphex was making its inspection

of the burrow. He placed it at a short distance. The Sphex, coming up again, was apparently agitated by the disappearance of its captive and sought for it energetically. Having found it, the Sphex drew it a second time to the mouth of the burrow, laid it down again, and proceeded to inspect afresh! This routine was repeated no fewer than forty times in succession, and the apparent compulsion to do things always in a given order is evidently strong. Although the burrow had been so often inspected, the Sphex had to do it again when it brought its captive cricket once more to the entrance.

Fabre's experiment certainly shows how thoroughly an instinctive animal may become the slave of routine. On the other hand, there are details in the story which suggest that the routine is not like the blind working of a machine. There was the energetic searching for the stolen cricket—a variation from the usual routine. There was, moreover, an incidental experiment made by Fabre. On one occasion he substituted for the paralysed cricket another specimen which had not been stung. When the Sphex came to drag it in, the cricket naturally resisted, and there was a keen struggle. It did not last long, however, for the Sphex soon leaped on its victim and stung it thrice. It is possible that intelligence took the reins at the critical moment. In any case the Sphex wasp showed itself to be something more than an automatic machine.

NUMBER XVIII

WONDERS OF INSTINCT

INSTINCTIVE activities are the outcome of inborn skill, which does not require learning or practice, though it may be improved by both. They are seen in their purest and most perfect expression in those creatures which belong to what Sir Ray Lankester calls the "little-brain" type, namely animals like ants, bees, and wasps. When we pass from these to the big-brained birds we feel at once a change of air; inference and learning are at work as well as the inborn inspirations of instinct. In what particular ways are instinctive activities wonderful, where all is wonderful?

The first marvel is the extraordinary perfection which instinctive behaviour often exhibits. Take the story that the great French naturalist Henri Fabre has told us of one of the solitary wasps, which we shall call the Fury. It shows extraordinary skill both in hunting and in building. With minute pebbles, and with earth moistened with the juice of its mouth, it builds a finely-finished cupola about three-quarters of an inch in height; the outside is covered with glistening grains of quartz or sometimes with tiny snail shells; the orifice at

the top is like the mouth of a Greek vase, gracefully curved, worthy of a potter's wheel. After the mother wasp has placed an egg in her well-fashioned nest, she adds five to ten small caterpillars, which she stings, and the next step is to close the orifice with a cement plug, in which there is always set a single tiny pebble. But the touch of perfection is to be found inside, not outside. It appears that the stung caterpillars that form the living larder inside the wasp's cell have still a good deal of vigour, and toss about when touched. Now the least pressure would crush the delicate egg. So it is hung by a thread from the roof of the cupola, and after the wasp grub hatches, it makes the shell of the egg into a flexible staircase so that it can reach the caterpillars and bite them, yet retreat if they are too fierce!

A second wonder is the way in which different operations are linked together in a chain. The grub of the Capricorn beetle burrows for three years on end in the depths of an oak tree. But when it is full-grown and the time of its change into a beetle draws near, it moves to the margin and makes a passage almost out, leaving only a film-like screen, just as if it knew that the winged beetle to come out of the pupa-case would otherwise be buried alive. It then draws back a little in its gallery and makes an outer barricade of particles of chopped wood, and inside that again a partition like a white skull-cap or acorn-cup, composed, strange to say, of carbonate of lime and some organic cement. The next step is to make to the inside of the partition

a transformation-chamber. This is three or four inches long, and is padded, Fabre tells us, "with a fine swan's down, a delicate precaution taken by the rough worm on behalf of the tender pupa." The next step is to fall asleep and dream of becoming a beetle. "The grub lays aside its tools, moults its cuticle and becomes a pupa, lying, weakness personified, on a soft couch. The head is always turned towards the door." This seems a little detail, but the strength of a chain is that of its weakest link. The supple grub can turn this way or that in its chamber, but the coming beetle will not be able to turn or bend. "He must absolutely find the door in front of him, lest he perish in the casket. Should the grub forget this little formality, should it lie down to its nymphal sleep with its head at the back of the cell, the Capricorn is infallibly lost; his cradle becomes a hopeless dungeon." But the grub forgets as little as it learns!

A third wonder of instinctive activities, which the observations of Henri Fabre illustrate very well, is that they are very apt to go wrong if there is anything the least unusual in the circumstances. Often subtle and perfect, without a loose thread from first to last, the instinctive routine may end in an almost ridiculous failure, when a grain of intelligence would have saved the situation.

Fabre once made a closed circuit of procession caterpillars on the rim of a palm-vase in his garden, and round this on a silken trail the creatures continued crawling and crawling for seven times twenty-four hours, working round and round three

hundred and thirty-five times and covering a distance of a good bit over a quarter of a mile. "The caterpillars in distress, starved, shelterless, chilled with cold at night, cling obstinately to the silk ribbon covered hundreds of times, because they lack the rudimentary glimmers of reason which would advise them to abandon it."

Instinct is the voice of the past, and it has to be obeyed even when it is fatal to do so. Instinct is not a low form of intelligence, it is more like an inborn inspiration. It works well for old ways, but not where *learning* is necessary. Instinct is wonderful, but intelligence is the more excellent way.

NUMBER XIX

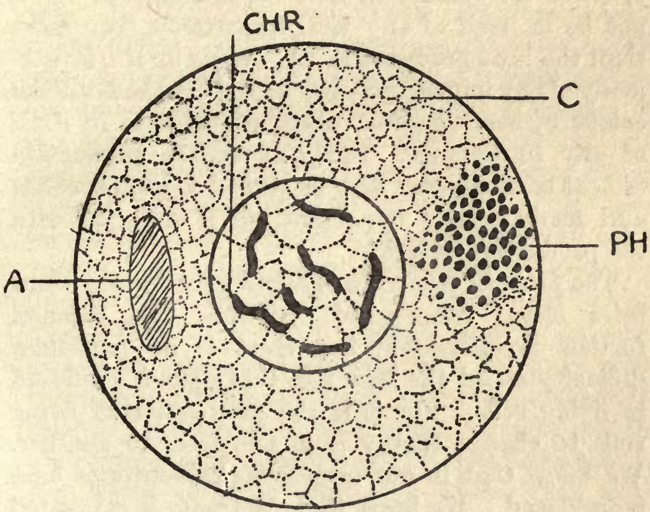
LIVING LIGHTS

LIFE is a powerful kind of activity. We see this activity in many forms—in the power of self-increase that is so characteristic of living creatures, one Infusorian becoming a million in a week; in the power of transforming matter, the green plant changing air, water, and salts into bread, the animal changing the plant into flesh. We see life's wonderful activity in the economical transformations of energy, for a living creature, considered as an engine, gives more return for the potential energy supplied to it (the food or fuel) than any engine of man's device; in the capacity for storing potential energy without much leakage, as in the trees of the forest; in the manifoldness of the energy-transformations that are accomplished, for we find one and the same creature doing work, giving off heat, emitting light, and exhibiting electrical changes. We get a glimpse of the wonder of vital activity in the exquisite responsiveness of living creatures, for a sundew tentacle will detect the presence of a minute drop of ammonium carbonate added to a large jar of water; the sensitive plant moves in answer

to "wireless" messages; and the earthworm, though without ears, is aware of the light tread of a thrush's foot. As a particular instance of the activity of life, let us take the power of giving forth light.

Luminescence

From the point of view of chemistry and physics, the living creature is a material system which



Luminescent or Phosphorescent cell. (*After* Watase.) C, General substance of the cell; CHR, Readily stainable bodies or Chromosomes of the nucleus—living constituents. A, Food; PH, Light-producing Granules—not living constituents. Oxygen acts on the granules, and Light comes from the cell as the result of oxidation.

effects the transformation of matter and energy.

It is the seat of continuous chemical changes—oxidations and reductions, hydrations and fermentations—which we sum up in the technical term, metabolism. There is no doubt that the production of light is one of the results of this metabolism. Just as heat is produced by the activity of the muscles and by all the combustions that go on in the body, so light is produced in connexion with other chemical processes involved in living. Many facts point to the conclusion that the luminescence need not be in itself of any vital importance, any more than the heat produced in the active brain is normally of any importance, any more than the beautiful colour of some organic waste products is in itself of any importance. But just as the production of heat or of pigment may be turned to good account and made vitally important, so it may be with the production of light.

The facts in regard to luminescence in organisms raise many unanswered questions and demand further investigation, but there is no particular difficulty about the bare fact that light is produced in living cells. For it is the prerogative of living cells to change energy from one form to another. We know that in our own living laboratories heat is produced. We know that electricity is generated in the living laboratories of the Electric Eel or the Torpedo. The production of light is just another instance of transformation.

Wide Occurrence of Luminescence

A noteworthy fact in regard to luminescence is its wide distribution in the sea. When the oars drip sparks on a summer night we see the luminescence of Noctiluca; and there are many open-water animals—some Radiolarians, some Medusæ, most Ctenophores, some "worms," many crustaceans, a few molluscs, Tunicates like the splendid Pyrosoma, and various surface fishes—which are luminescent. In the shore area there are luminescent Echinoderms, especially Brittle-stars; the boring Pholads—with their miners' lamps; and various members of the alliance of Stinging Animals. In the great abysses luminescence is common, e.g. among Alcyonarians, Medusæ, Echinoderms, Crustaceans, Cuttle-fishes, and true fishes. On land we know it best in glow-worms, fire-flies, and other insects, but it also occurs in some Myriopods (e.g. *Geophilus electricus*), and in some earthworms (e.g. *Photodrilus*). It is usually said to be quite absent in freshwater animals, but we have some suspicions as to the accuracy of this generalization, bearing in mind a freshwater relative of the glow-worm and allegations of luminescence in the larvæ of some Harlequin flies. That there are phosphorescent Bacteria is well known—every one can see them on fish hung up to dry—and it is probable that reports of luminous birds are due to luminescent fungi on the plumage.

In a case like the luminescence of Bacteria, no one even looks for any utility. The luminescence is a

by-play of vitality; it is one of the residual powers of the living creature; and it is probably exhibited in many cases in which we do not and cannot see it. What we need to know is (1) the internal physiology of luminescence, and (2) what its use may be in cases where it bears the marks of specialization.

The luminescence is in some cases indissolubly connected with the cellular metabolism—as in Noctiluca, Brittle-stars, and some fishes. When the cells die the light goes out. In other cases the luminescent material is not luminescent until it is exuded from its producer into the water, as in many minute Crustaceans called Copepods. The light does not require contact with life to keep it shining. The trail of the luminous Myriopod shines in the dark, and in some cases (Copepods and Pholads) the luminous secretion can be dried and yet retain its capacity of giving forth light when it is put into water after several days, weeks, or months.

In the American Lampyrid beetles, popularly called fire-flies, the light-producing organ consists of two layers. The inner one, white and opaque, seems to serve as a reflector, and perhaps protects the insect from its own brightness. The outer one, yellowish and translucent, is the seat of the actual light-producing process. It is interesting to know that innumerable air-tubes or tracheæ penetrate the organ, for this bears out the conclusion otherwise arrived at, that the luminescence is often due to an oxidation. In other cases, however, it seems that the luminescence is associated with a kind of fermenting. Sometimes it is possible

to distinguish a light-producing material and a ferment which sets the production agoing.

In the American fire-fly both sexes are luminescent, the flightless female less so than her active partner. The luminescent organs of the male consist of a pair of plates, lying beneath the skin on the under side of the fourth and fifth posterior segments. Each plate has two layers, and the lower is built up of polygonal cells filled with coarse granules. In this lower layer there is probably a rapid oxidation of some unstable substance, perhaps of a fatty nature. It is possible that the rapid breaking up is quickened by some ferment. Very noteworthy is the fact that the light is unaccompanied by perceptible heat. It is therefore produced more economically than in any of our lamps, where some of the energy is always lost as heat.

In the fire-flies of the genus Luciola the light given off has a beautiful green "fluorescence," and is able, like X-rays, to affect a photographic plate through opaque layers of wood or leather.

In an interesting study on the luminous organs of cuttle-fishes, Dr. W. E. Hoyle calls attention to their occurrence in so many and such scattered families that repeated and independent origination seems probable. They are almost always on the ventral surface of the cuttle-fish, but they occur there in nine different situations. Sometimes they are concealed beneath the skin, but they may be effective even then, since the living tissues of cuttle-fishes are very transparent. It is plausible to suppose that they serve as recognition marks, and that they

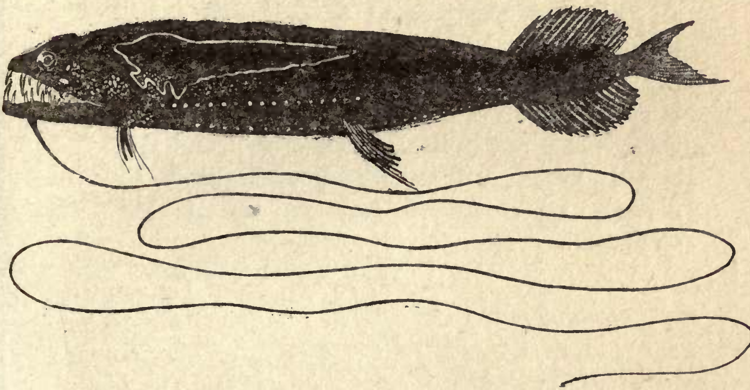
act as searchlights, playing over the floor of the sea. Some of them are simple, but others have a complicated optical apparatus with some or all of the following structures—pigment layer, reflector, lens, and diaphragm.

In two surface fishes of the Malay Archipelago (which have very big mouthfuls of names—*Anomalops katoptron* and *Photoblepharon palpebralis*) there are large luminous organs about the head, which seem to give out a constant light without requiring any particular stimulus. The luminescence has its seat in material secreted by glandular cells, and occurs outside the cells in the cavity of the gland. The luminescent organ can be, so to speak, extinguished by a downward movement, which possibly takes place when an enemy appears on the scene.

A very remarkable deep-water fish, named Lamprotoxus, has been described from the south-west coast of Ireland. It has a filamentous feeler many times longer than the body. The colour of the scaleless skin is velvety-black and the feeler or barbule is grey. A purplish-grey band of luminous cells, partially embedded in the skin, forms a closed loop on the anterior part of the body. There is also a large "lamp" behind and slightly below the eye, shut in by skin save for a narrow slit; and there are numerous minute lamps.

There is little direct evidence as to the use of luminescence, and, as we have said, there are probably many cases where it is of no use. But this cannot be the case when it is associated with very

complicated organs. And when we see a female glowworm with luminescent organs on the under side of the body turning herself back downwards with the result, at any rate, that her light is visible, we find it difficult to believe that the light is not a signal to the male. Many animals move towards a light, and it is a very probable view that the luminescence of many marine animals helps to bring food



A remarkable fish, *Lamprotoxus flagellibarba*, from deep water off S.W. of Ireland. The small spots and the "looped band" seem to be luminous organs. The feeler or barbule is many times longer than the body, which is about seven inches in length. (*After* Holt and Byrne.)

to them. Professor Max Weber mentions the very interesting fact that the fishermen of Banda cut out the luminous organ of certain fishes, such as Anomalops, which we have mentioned already, and use it as a bait, for it keeps on shining for hours. A sudden illumination of a luminous organ, or a sudden

discharge of a luminous secretion, may have a protective value. In the darkness of the great abysses some animals may possibly use their luminous organs as lanterns. Where the luminous organs are arranged on a definite pattern—which is sometimes different in the two sexes—it is quite likely that they serve as recognition marks, helping members of the same kind or species to know one another at once.

There is plainly much of the "perhaps" about all this, but the general idea stands out that a transformation of energy comparable to the burning candle—chemical reactions producing light—is of frequent occurrence among animals, and that though it is not in itself necessarily useful, it may be seized upon, utilized, and elaborated towards diverse advantageous ends in diverse kinds of creatures.

NUMBER XX

THE BIG TREES

THE "Big Trees" or Sequoias of the western slopes of the Sierra Nevada range and the "Redwoods" of the coast ranges are the magnificent survivors of an ancient stock (dating from the distant Cretaceous Period) that once spread over the Northern Hemisphere, but was brought near to an end by the severe conditions of the Great Ice Age. In size, majesty, vigour, self-healing power, and antiquity these "Big Trees" command our admiration. They have also the distinction of having had a longer life than any other living creatures—they make centenarians and the like appear youngsters.

The late Prof. W. R. Dudley made some careful records on this subject. "Of the various trunks of *Sequoia gigantea* examined ranging from 900 years upward, the oldest possessed 2,425 rings, or had begun its existence 525 years before the Christian era." A tree near a perennial stream was over 80 feet in circumference ten feet from the ground, but was only 1,510 years old; another growing on a hillside, not near a stream, had suffered from fire and from privations (fifty rings of scarce years

not covering an inch), and it was only 39 feet in circumference ten feet from the ground, but it had attained the age of 2,171 years and a height approaching 300 feet.

Professor Dudley showed the extraordinary vitality of the Big Tree by tracing out the way in which many of them had been able to "heal" or cover over great wounds made by fire. What a tree does is not to revive what has been killed—that is impossible—but to extend or fold its living tissue over the wound. The covering process may take scores of years.

The tree already referred to, which began its existence in 271 B.C., was about twelve feet in circumference (just above the base) at the beginning of the Christian era. When it was 516 years old (A.D. 245) it suffered a burn three feet wide, and 105 years were occupied in healing this wound. When it was 1,712 years old (A.D. 1441) it suffered two bad burns. One hundred and thirty-nine years of growth followed, including the time occupied by the covering of the two wounds. When it was 1,851 years old (A.D. 1580) it suffered from a burn two feet wide which took fifty-six years to heal. When it was 2,068 years old (A.D. 1797) a tremendous fire burned a great scar 18 feet wide with a height estimated at 30 feet. In the 103 more years that it continued to live before it was killed, the tree had reduced the wound to fourteen feet in width, and it might have finished it in A.D. 2250, or thereabouts. This "Big Tree" stands practically alone, "sublime among living objects in its ability to withstand an injury

of this magnitude, and to endure a sufficient length of time for its complete recovery." The resistance to insect, fungus, and microbe is hardly less remarkable. "There is something in the sap of the Big Tree that is an elixir of life, something deposited in the layers of wood that resists in an unexampled way the dreadful 'tooth of time.'"

One does not envy the man who can look at even a section of a great Sequoia without a thrill at the sight. "We have, deep in their annual rings, records which extend far beyond the beginnings of Anglo-Saxon peoples, beyond even the earliest struggles for liberty and democracy among the Greeks," . . . "records of forest conflagrations, of the vicissitudes of seasons, of periods of drought and periods of abundant and favouring rains." It is to be hoped that everything practicable will be done to protect these triumphs of life—these sublime instances of its power and endurance.

AUTUMN

NUMBER XXI

AUTUMN

THERE is aptness in speaking of autumn as "the fall," for life then begins to go on the down-grade. It is the ebb-tide of the year. And just as it is the sun that quickens the seeds, raises the sap, unpacks the buds, and opens the flowers, and our hearts as well, in spring, so it is the lack of sun that now casts a spell upon life, putting the fires out and making us melancholy in the autumn. It is the year's curfew and its vespers. When the chimes cease we know the silence for winter.

Autumn a Time of Preparation

Even the careless, who pause only for a moment to listen to the curfew of the year, must perceive the sadness of the notes. They are heard in the calls of the birds passing south who "wail their way from cloud to cloud," in the rustle of the falling leaves, and in the piping of a mournful wind which bears both birds and leaves away. Autumn is a time of withering and leave-taking.

But a more careful listener will hear very different notes, which tell of the continuance of life in spite of death, of preparation for the future amid the

withering of the present. The farewell that seemed for ever is often more accurately "Au Revoir," "Auf Wiedersehen." For the tide of life which has now turned in ebb is not one that sinks sullen and empty from a rocky shore; it is rather like that which bears from some great seaport a fleet of richly laden ships. The ebb of the year is the time when fruits ripen, when seeds are scattered and sown; it is not an end, it is a new beginning. There is indeed stranding and wreckage, as the dead birds among the jetsam tell us plainly; but the autumn fruits are more characteristic. They crown the plant's work for the year, and form the cradles of next year's seedlings; they protect the young lives within the seeds, and also secure their dispersal. Many of them harden, crack and split like withered leaves, which is just what many of them are; others swell and soften into succulence.

Amid much Death abundant Life

The drops of water rise to the apex of the sunlit fountain, enter for a brief moment into the formation of a rainbow, and are hurried to the earth again. Such is life. The organism rises to the crest of the wave, reaches its limit of growth, and reproduces; then is hurried from the climax of loving to the last crisis of dying. So all around us in autumn we see the little child Love, as in the world-famous picture, holding the door against stalwart Death who intrudes. The curfew tolls, the fires of life burn low, the lights of love die out, the petals of the last poppy are shed, the butterflies disappear with the sunbeams which

danced with the glistening leaves, and lowering storm-clouds draw a shroud over the earth.

Yet in the midst of death in autumn we are impressed with the abundance of life. For autumn is the time of seed-scattering. The cotton-grass has unfurled its white sails on the moor; clouds of thistledown and ragwort nutlets with equally dainty parachutes are swept over the waste; the hooked fruits of burdock, cleavers, hound's-tongue, and how many more, cling to our clothes and to the sheep's fleece; all sorts of pods and capsules have opened, and gusts of wind—how much more the equinoctial gales—have scattered and in many cases sown the seeds. The prodigality is as unmeasurable as it is providential. And so, on this fine autumn day, the harvest carts pass heavily laden with sheaves, strong coveys of partridges darken the stubble, the links are crowded with rabbits, the air is full of whirling seeds, the fallow ground is vibrating with the gossamer threads of small spiders that have sunk to earth and gone into hiding, the apples fall in showers in the orchard, and we wonder, as men have wondered for thousands of years, at the Abundance of Life.

The Falling Leaves

Nothing is more characteristic of autumn than the rustle of falling leaves. Beneficent in their life, for all the plant's wealth is due to them, they are beautiful in their dying. Before they die they surrender to the plant all that they have still left that is worth having. They are like empty houses

from which the tenants have flitted, breaking and burning some of the furnishings as they went, leaving little more than ashes on the hearth. But Nature is ever generous of beauty, and the dying leaves have a literal "beauty for ashes."

The Departure of the Migrant Birds

We hear another note of autumn when we listen to the calls of the migratory birds, as they pass overhead by night, or congregate with excited clamouring before starting on their southward journey. It is the note of autumnal restlessness.

Many are already gone, for the tide turned in midsummer; "the last spent pulses of the great vernal wave of migration have scarcely ceased to flow, before the first ripples of the autumn tide begin to be apparent." Many have slipped away, singly or in pairs, without a good-bye; others are still making up their minds, making many "last appearances," telling us excitedly day after day, "We are going, we are going."

That they should go we do not wonder, for the leaves are fallen from around their old shelters, the fruits have been gathered or scattered, the seeds are sown, most insects are dead or in safe resting-places, the daylight is short for picking up the scraps of life that remain within reach, it is becoming colder every week. We draw our cloak about us shiveringly, as we wish the last migrants "Bon voyage!"

To meet the Winter

Life has been defined as a struggle to avoid death,

or as an effort towards continuance, and we undoubtedly miss part of the Biology of Autumn if we do not recognize it as a time of preparation for continued life.

The plant has been storing all summer, and now the reserves are all passing from the more perishable parts, from leaf to stem, from stem to root. There are stores in many buds, well protected by scales which, themselves dying away, save the delicate life within ; there are stores in seeds, similarly protected by dead husks ; and so it is with tuber and root-stock, corm and bulb, all are stores. The beavers store branches cut into convenient lengths, the squirrels store nuts, the field-mice grain, the moles earth-worms, and so on through a long list. Many insects store provender for offspring which they will not survive to see. Some ants store grain, biting at the embryo and thus preventing germination ; others chew grain and store it in biscuit form ; a few take their cows—the Aphides—with them into winter quarters. It is said that hive-bees become lazy in countries where there is practically no winter, which corroborates the suggestion that the success of North Temperate peoples is partly due to that discipline in foresight, as well as to the punctuation of life, which the marked seasonal changes impose.

The Rest of Autumn

Autumn is the evening of the year, the beginning of rest, the curfew, as we have said ; but we must correct the picture of a dying world with a thought

of the rest which is given in sleep. The trees, some of them already bare, the wrapped-up buds formed months ago on the boughs, the seeds buried in the ground, the chrysalids hidden in quiet resting-places, the eggs and larvæ under still waters, the clammy frogs in the mud of the pond, the reptiles and mammals who have found their winter nests—they are not dead but sleeping. They await the good-morning of another spring, and though to some this never comes, of most it may be said that if they sleep, they shall do well.

We have spoken of autumn as the curfew of the year partly because of the covering-up of many vital fires that is then enforced, and partly also because of a memory of curfew bells we used to hear in a country village long ago, which seemed always to sadden and gladden in alternate notes—saying, "Night and Morning, Death and Life; Night and Morning, Withering and Sowing; Night and Morning, Weariness and Rest; Night and Morning." This was a fancy, perhaps, as regards the bells, but it is a fact as regards autumn.

Climb the hill above the village, and watch the sun set over the withering woods. Look out over the sea of gold, mingled with fire, and broken by dark rocks which you know to be pines. Accept the withering, but see also the harvest-fields; even on the bare boughs there are buds. Hear the birds pass overhead, quite a babel of good-byes sometimes, but many at least will return. Watch the seeds drift off the dead plants as the wind sighs along the hillside, and know that the race continues. Look

Death in the face, and try to see that he is, on the whole, kindly and wise.

Wait till the colours pale in the short twilight, till the cows are driven home lowing, till the sheep are herded off the exposed moorland lest snow come in the darkness, till the birds that remain cease to call, till the lamps are lit in the cottage windows. Wait on till the curfew tolls, till the lights are put out one by one—then know the rest and silence of autumn.

NUMBER XXII

THE MIGRATION OF BIRDS

MIGRATION is a regular annual flitting between summer quarters and winter quarters, between a breeding or nesting place and a feeding or resting place. And one of the big facts is that birds always nest in the colder area of their migratory range.

For the Northern Hemisphere bird-migration is the rule, not the exception, but it differs greatly in its range. In many parts of Scotland the curlews pass at the beginning of winter from the exposed moorland to the neighbourhood of the seashore, where it is easier to procure food. This is migration with a short range. It may be contrasted with that of the Arctic tern which the *Scotia* explorers found "wintering" in the Antarctic summer in 74° S. lat.—the greatest of all known migratory ranges.

The birds of any country in the Northern Hemisphere can be grouped, from the migration point of view, into five sets :—

(1) There are the summer visitors, such as, in Britain, the swallow, swift, cuckoo, nightingale, and so on through the long list (mostly insectivorous,

one should note), who arrive from the south in spring, nest and breed within our bounds, and return in late summer or autumn "to warmer lands and coasts that keep the sun."

(2) Against these we have to place the winter visitors, such as fieldfare and redwing, both first cousins of the thrush, the snow bunting, and many of the northern ducks and divers, who nest in the far north, but come south in winter.

(3) In a set by themselves we may rank the birds-of-passage in the stricter sense, like some of the sandpipers, the great snipe, and the little stint. They rest, for a short time only, in a country like Britain, on their way farther south or farther north.

(4) Then there are the "partial migrants," who are always represented in the country in question, but not always by the same individuals. That is to say, some individuals leave the country and others do not; and the place of those who go is often taken by other individuals from elsewhere. Thus in many parts of Scotland one may see lapwings every month of the year, and yet there is a regular autumn migration of lapwings from Scotland to Ireland. There are always goldfinches to be found in the South of England, but there is a regular migration southwards in October and a corresponding return in April. Recent work has shown that the list of "partial migrants" is a long one—longer than used to be thought.

(5) There remain the strictly resident birds—such as, in Britain, the red grouse and the house sparrow, the rook and the robin.

PUFFINS—A GOOD INSTANCE OF "SUMMER VISITORS."

Perhaps another division should be made for the interesting "casual vagrants" who occasionally turn up in a country far off their normal range. The American kildeer plover shot in Aberdeenshire in 1867 is a good instance.

The migration of birds is a seasonal flitting, and there is a contrast between the autumn and the spring movements. The autumn migration, on the whole southwards, is less hurried than the return migration in spring. There is often a good deal of fuss and dallying before the autumn migrants get fairly under way. They make trial journeys and may begin their pilgrimage with short stages. The young birds are said to get restless first; the old males are said to linger longest. It may be that the adults are kept back by the need of rest after their family cares, and also by a moult after which the feathers damaged by the summer's wear and tear are replaced.

In spring, on the other hand, the movement is keener and more rapid. The full-grown males seem usually to take the lead; then follow the full-grown females; the younger birds, who will not breed for a season or two, bring up the rear. Thus the spring order is the reverse of the autumn order. There is some evidence, also, that the spring journey is more direct than the autumn journey. Short cuts are found and haste is evident. It is interesting to notice Audubon's observation in reference to the American rice bird, that it flies in spring by night, and in autumn by day.

Another general fact in regard to migration is its

regularity and success. When weather conditions are very unpropitious, there is often great mortality. The streets of towns are sometimes strewn with thousands of birds that have gone astray and have perished in the cold. As many as five hundred nightingales have been gathered in a single day from one small town. But, on the whole, the striking fact is not the number of failures but the large proportion of successes. This is the more striking when we think of the difficulties of a long migration journey. What we are made to feel is that migrating is an old-established business; it has been going for so many hundreds of thousands of years that it now works very smoothly. A thrush born in the North of Scotland was found at the end of its first summer near Lisbon—a long journey for an inexperienced traveller who is hardly counted as a migrant at all. And there are many similar instances.

The feature of regularity is also seen in the remarkable punctuality of arrival and departure which is often exhibited, except, indeed, when the weather conditions are unusual. Fog and head-winds may delay arrival; a summer that has favoured the increase of insects may induce birds to postpone their departure; but, on the whole, there is a remarkable regularity in the comings and goings.

Still more remarkable is the fact that in some cases there is conclusive proof of a bird's return to its birthplace. A swallow marked as a youngster with an aluminium ring has been known to return the following year from its winter quarters, not

merely to the same county or parish, but to the same farmyard. The same return to the original homestead has been proved in the case of the house-martin and the stork, and is certainly one of the most wonderful facts about migration.

Difficult Questions

Comparatively little is yet known in regard to the paths that birds follow in their migratory flight. From the shores of the Baltic the storks migrate in autumn southwards and south-eastwards to South Africa. Many swallows seem to fly more or less directly from north to south. Many birds, such as hooded crows, show in autumn a great westward movement along the shores of the Baltic, with a subsequent curve towards the south. Some contingents swerve southwards by the valleys of the Rhine and the Rhone, and then across the Mediterranean to North Africa. Other contingents seem to go farther westwards, crossing, it may be, by way of Heligoland to the South of England, and thence across to France, Spain and Portugal, finally landing like the others in North Africa. These are but a few examples of known routes.

Other matters for investigation, which must be patiently continued without hurrying towards an answer, are the altitude and the velocity of the migratory flight, and its relation to weather conditions. While enormous armies of larks, starlings, thrushes, and some other birds have been seen flying very low across the sea, it is probable that most migrants fly at a considerable height. Careful

observations lead to the conclusion that it is very unusual for birds to migrate at altitudes above 3,000 feet. Some astronomers, however, report seeing birds at elevations of 10,000 feet.

Gätke estimated the speed of migrating plovers, curlews, and godwits, crossing Heligoland, at nearly four miles a minute, and he calculated the speed of hooded crows, crossing the North Sea, at 108 geographical miles per hour. Dr. J. Thienemann's observations at Rossitten in 1909 led to lower averages such as the following: Sparrow-hawk, $25\frac{7}{8}$ miles per hour; hooded crow, $31\frac{1}{4}$; rook, $32\frac{1}{2}$; chaffinch, $32\frac{3}{4}$; linnet, $34\frac{3}{4}$; peregrine falcon, 37; jackdaw, $38\frac{1}{2}$; starling, $46\frac{1}{3}$.

It is reported that a marked swallow flew from Compiègne to Antwerp, about 145 miles, in 1 hour 8 minutes! It is certain that many a bird may attain in its everyday life to a velocity of fifty miles an hour, and it is probable that twice as fast is a safe estimate for the rate of many a migratory flight, when the whole life is raised to a higher pitch.

As to meteorological conditions, it becomes increasingly clear that birds in their migrations are somewhat strikingly indifferent to the weather, unless, indeed, it reaches a high degree of storminess or fogginess or unpropitiousness generally. It seems that the weather conditions which obtain when and where a mass movement begins are of much more moment than those into which the birds pass in the course of their flight.

Deeper Problems of Migration?

It is interesting to inquire where we should rank migration on the inclined plane of animal activities, but no secure answer can be given in the present state of science. It seems to partake very largely of the nature of instinct, that is to say, birds have a specific hereditary preparedness or disposition for their migratory movements, which enables them to go through with them without education or experience. But this does not exclude the view that birds have their wits about them as they fly, for many instinctive activities show a spice of intelligence. Nor does it exclude the view that birds migrate more successfully as they grow older, for instinctive routine may be intelligently perfected by practice. That the migratory activity has an instinctive basis is suggested by its regularity and orderliness, without much individuality and with little hint of caprice; and by the preparations made before there is any real need. Moreover it must be remembered that none of our summer visitors have any personal experience of wintry conditions, literally knowing no winter in their year. The idea of instinctive or inborn predisposition and capacity is also suggested by the success with which many young birds carry it through, apparently unguided and untutored; by a few observations of the restlessness shown at the proper time by comfortably caged migrants; and by the occurrence of other true migrations in widely separated divisions of the animal kingdom.

Periodic movements occur in many other creatures

besides birds—in land-crabs, in fishes like salmon and eel, herring and mackerel, in turtles, in lemmings and field mice, in some deer, in eared seals and in most cetaceans, such as the bottle-nose whale, the right whale, and the white-beaked dolphin. The term migration should not be used, however, without qualification, unless the movement is really periodic—a recurrent seasonal movement. Thus we regard the turtles' voyage to the egg-laying beach as migratory, while the lemmings' march is not. Similarly the movements of the salmon and the eel are much more worthy of being ranked as migratory than are those of the mackerel and herring.

If it be granted that the migratory activity has an inborn instinctive basis, we look none the less for the immediate causes or stimuli which pull the trigger twice a year at the proper time. In the case of the autumnal movement, we think of the increasing cold and the decreasing shelter, of stormy weather and the shortening of the daylight hours available for food-collecting, and of the dwindling supply of insects and slugs, fruits and seeds, and so on. But we shall probably go wrong if we regard these unpropitious conditions as more than the trigger-pullers of prepared states of body and mind.

The stimuli that prompt the northward journey in spring are more difficult to state, especially when we take into account the great diversity of the winter quarters and the fact that a large proportion of the returning migrants are immature. Probably the conditions of temperature, humidity and food-supply are such as to exclude, for many kinds of

birds, the possibility of nesting in the south. Perhaps in some cases the bird's constitution is such that it cannot mate and nest without the subtle stimulus implied in a return to the conditions of the original birthplace. Perhaps too there are lingering memories of the abundant and pleasant food—whether berries or mosquitoes—to be had in the north. As regards both nesting and feeding, there may be a sort of constitutional home-sickness.

It is difficult to say anything very useful at present in regard to the origin of the migratory habit. Perhaps the establishment of two homes or territories has been wrapped up with the history of climates which have changed greatly in the course of ages. Perhaps it had more to do with the food-supply. Many birds are prolific, and overcrowding is apt to occur. Instead of crowding in one area all the year round, and involving themselves in want, birds learned, like the Swiss peasants, to exploit two areas, each for about half of the year. They tended to push farther and farther northward in spring, exploring and exploiting new grounds, staying as long as they could, and retreating before the breath of winter to their home in the south. It was probably most effective to go as far north as possible before settling down to family life. A noteworthy fact is that the birds with the largest families tend to have the widest migratory range.

However the migratory habit originated, it is not difficult to understand that individual birds who were dull, sluggish, wilful, or foolish would tend to be sifted out year after year, age after age, and that

this would gradually raise the standard of migratory capacity.

How do Birds find their Way

The most difficult question in regard to the migration of birds is: *How do the birds find their way?* We cannot at present give an answer. For many years yet it may be necessary to work patiently at easier questions, such as: *What way do they find?*

No doubt the wonder is great that birds return from the south to their birthplace in the north; that inexperienced young birds make a long journey, often overseas, to suitable winter quarters, with success in a large proportion of cases; that they keep their direction in the dark and at great heights and while flying over pathless waters. It is true that there are many failures, a crop of tragedies every year, a never-ceasing sifting, but the marvel is that there are so many successes in one of the most daring of life's adventures. We cannot answer the question, but it is interesting to notice some of the many suggestions that have been made in regard to the way-finding. (1) It has been suggested that success in way-finding may be due to inherited experience, growing from generation to generation, enriched year after year by many little contributions. But no one can be sure that experience can be handed on in this way, and it is very difficult to explain what the experience would be in the case of birds flying by night, often at great heights, and across the sea, as so many do.

(2) An attractive theory is that of social tradition,

THE CUCKOO.

and in this there may be some truth. The idea is that those lead well one year who followed well for several years before. There may be some old experienced birds amongst that rushing troop of youngsters. But the difficulties are great. How could the old hand become *experienced* in the matter of a night journey across the Mediterranean? In the case of the cuckoo there does not seem to be a single parent bird left in Britain when the youngsters begin to migrate. But there is no evidence that cuckoos are less successful migrants than other birds. It has been said that they may migrate with their foster-parents, but this, if true, cannot be the whole truth, since a number of the birds who act as foster-parents do not migrate.

(3) A third theory, that has a great deal to be said for it, lays all the emphasis on sensory alertness. Birds have very keen senses of sight and hearing; the migrants *sometimes* follow coast-lines, river-valleys, lines of islands, and so on. But it is quite plain that this cannot be the whole answer, since many birds migrate by night and at considerable altitudes. Nor are there any landmarks in the open sea.

(4) The fourth suggestion is almost certainly in part true, that birds have "a sense of direction," which takes two forms—a power of flying continuously in a definite direction, and a power of finding their way home. In regard to the second, we all know something about the "homing" powers of cats and dogs, cattle and horses. Even when the cat is put in a basket, and taken in a cab, and then in

a train, it may find its way back. It is true, however, that we do not hear very much of the cats who left their second home and did *not* return to their first home. If a hive-bee, issuing from the hive, be caught and imprisoned in a box and put into a pocket, and be thus transported for an intricate half-mile, and then released, it ascends into the air, and makes a "bee-line" for home. The "homing" of pigeons is also a certainty, and the value of it is not lessened by knowing that the power can be greatly increased by training. But if we suppose that birds have in a high degree the sense of direction and the homing faculty, we are not, of course, explaining the wonder of the migratory bird's success in way-finding, we are only saying that it does not stand so much alone as it seemed at first to do.

NUMBER XXIII

HOMING OF SEA-SWALLOWS

HOMING pigeons have been used by man for more than two thousand years, and we know that after some training they are usually successful in returning from great distances to their cots. But we do not understand how they manage to do this. Still less can we explain the fact that a swallow may return from its wintering in Africa to the Scottish farmstead where it was born the year before.

Some very interesting experiments on the homing of sooty and noddy terns (or sea-swallows) have been recently made by Professor J. B. Watson and Dr. K. S. Lashley. They worked at Bird Key, one of the islands of the Tortugas group at the mouth of the Gulf of Mexico, where the terns nest in tens of thousands. It is the most northerly part of the terns' migrating range.

The experiments are as follows: A bold, vigorous tern is caught, it is marked with oil-paint on the head and neck; two tags (small and large, but otherwise duplicate) are prepared, recording the date, the place, and the kind of marking; the small tag is tied round the bird's neck; the large tag is

TERNS OR SEA-SWALLOWS ON THE SHORE.

fixed to a foot-long stake pushed down into the sand near the nest if the bird is a Sooty, or tied to a convenient twig if the bird is a Noddy; the bird is put into a large hooded cage and transported to a distance on board ship; it is kept in good health with minnows from the refrigerator; it is liberated at a chosen point; and then its return to the nest is watched for. The most important result is that these terns are able to return from Galveston, more than 800 miles away, over a great tract of open sea. Some returned in about six days, some took nearly twelve, some did not return at all. Many of the return journeys from distances greater than 500 miles did not require more than three to five days, but sometimes as long a time was required to come from Key West to Bird Key, which is only about 65 miles.

Two Noddies and two Sooties were taken in the state-room of a steamer to Havana, and liberated in the harbour there early on a July morning. They returned to Bird Key (108 miles off) next day, having probably spent most of the time resting and feeding around the shores of Cuba. Five birds were taken as far north as Cape Hatteras; three returned in a few days, having accomplished a journey of 850 miles as the crow flies, and of much more if the alongshore route was followed. Four Noddies and four Sooties were taken in a hooded cage on a Galveston steamer to about 461 statute miles from Bird Key and liberated where no shore line was visible. "On release all birds with one exception started east. That one headed west and continued

for about 200 yards, then turned suddenly and started east." They had a strong head wind against them throughout the first day, but two of the Noddies returned in safety to Bird Key.

We do not know how the homing is managed, but it is something to be sure of the fact that untrained birds can return successfully across the apparently trackless sea from a distance of 800 to 1,000 miles. Perhaps we should notice that these terns that returned so successfully were nesting terns. They went home to their nests, that is to say, to activities in which their life reaches its highest level. They were moved evidently by some deep impulse which would not be thwarted by any waste of seas.

NUMBER XXIV

COUNTRY SOUNDS

IN temperate countries, where violent changes are rare, most of the sounds in the world of things, apart from living creatures, are subdued. There is, indeed, the roll of the thunder, the battery of the sea, the howling of the storm, the crash of avalanche and landslip, the roar and cannonading of the forest fire, the groaning of the earthquake, and the booming of the cataract, but all these are more or less unusual. What we are more accustomed to, what we have come to love, are gentler, subtler sounds with some music in them—the sob of the sea, the sough of the wind in the wood, the song of the purling brook, the crickle-crackle of the brittle withered grass and shrivelling herbage, the sigh with which the parched ground receives the heavy rain, and the little sound that the breeze makes when it rings the sun-dried bluebells by the wayside, or causes the aspen leaves to quiver, or sets the heather tinkling, or gives a whisper of gossip to the bulrushes beside the lake.

For many millions of years the only sounds upon the earth were those made by things without life; it was not until living creatures had been cradled and fostered for many ages that they found voice.

Insects were the first to break the silence, and their sound-production is almost wholly instrumental. Buzzing or humming is mainly due to rapid vibrations of the wings, which often strike the air more than a hundred times in a second, but there is sometimes a special quivering instrument near the base of the wing. Chirping or trilling is due to one hard part being scraped against another, as the bow on the fiddle—it may be leg against wing, or limb against body. A true voice, due to the vibration of vocal cords as the air from the windpipe passes over them, began in the amphibians, but did not come to its own till birds and mammals appeared on the scene.

As the sounds made by not-living things in Temperate zones are, on the whole, less violent than those of the Tropics, so is it also with the sounds made by animals. How little we have that can be compared with the chatter of parrots and monkeys in warmer countries! Except during the time of bird-courtship a North Temperate country is very quiet.

We went in the August gloaming to a beautiful lake hidden in a forest of Scots pine and spruce. As far as one could see there were only two birds visible, a pair of dabchicks, diving every minute or two, and uttering now and then the gentlest possible *whit-whit* which one would not have heard if the hush had not been so great. Now and again a silvery trout leaped high; but that was all—till suddenly a ring-dove gave voice, with its deep, rich *coo-roo,* wonderfully soothing and tender.

Just as people vary considerably in acuteness of

vision, so some hear many sounds which escape others. Thus some can detect the stroke of a bat's wing and the closing of its jaws on an insect, the munching of a caterpillar, and the rustle of an earthworm.

In midsummer in the North of Scotland, for instance, there is hardly any darkness at all—one can sometimes see to read at midnight, and there are not more than two hours when the larks are not singing. But even when there are long hours of darkness there are country sounds. There is the hedgehog, for instance, which calls incisively in the stillness with a peculiar voice between grunt and squeal. There is the whir of the night-jar and the loud clap of its wings together, as it hawks for nocturnal insects, or the vibrating "churr" of the male seated lengthwise on a branch. The shriek of the barn-owl and the *tu-whit, tu-who* of the tawny owl are familiar night sounds, and some people can hear the voice of bats. Soon after cock-crow one is wakened by the rather startling bark of black-headed gulls, and they are soon followed by the more cheerful jackdaws. Then, on the adjacent moor, the cock grouse welcomes the sun; the swifts, soon to journey to the south, begin their chase, and their half-triumphant, half-delirious cry, in bad weather and in good, is often the first sound to be heard in the morning and the last sound to be heard at night.

Particular places have their characteristic sounds, which we listen for expectantly. The moorland would be incomplete without the melancholy cry of the curlew, with a melodious ripple at the nesting-

time; in the bed of the stream we wait for the oyster-catcher's alarm-whistle *keep-keep*; by the estuary we enjoy the redshank's warning call with a pleasant trill in it, which the male raises to a higher power in spring; among the furze-bushes beside the dry wall the stonechats seem to "chap" the stones together; the peewits cry plaintively from the farmer's fields; as we take a short cut across the heathery "preserve," grouse after grouse proclaims our trespass with a ridiculously silly cachinnation *kok-kok-kok*; but best of all we like "the moan of doves from immemorial elms."

Around all the country-sounds that have become dear to us there have gathered memories, associations, ideas, and we hear with more than the hearing of the ear. There are wonderful "wireless" messages which the imagination can catch. As we walk at nightfall across the common, noiselessly we think, a dog barks just once or twice from a cottage door half a mile away, and then, before the utter quietness is resumed, we hear the children turn in bed, the click-clack of their mother's knitting-needles, the rustle of the newspaper which the shepherd is reading by the fireside. So is it with the other familiar country sounds; we hear not them alone, but what they are symbols and echoes of; for man is ever reading himself into the so-called outer world. It is his particular magic to hear in the lark's miracle of song the music of Shelley and the wisdom of Meredith, to infer the cherubim from the chaffinch, and to find in the "lily-muffled hum of a summer bee some coupling with the spinning stars."

NUMBER XXV

THE FALL OF THE LEAF

LATE autumn, which marks to many of us the beginning of winter work and winter pleasures, means to the wide world of life an ebb-tide. It is sometimes, indeed, a period for rest and repair, or, as is often the case, a time for dying, but it is always an ebb-tide. And one of the very beautiful signs of this, more striking than the homing of the birds or the winter sleep of mammals, is the fall of the leaf.

The life of the plant is like a tide; it sets in with a flood in spring, manifesting itself in growth of stem and exuberance of foliage; it rises to the high-water mark, and turns in summer when the blossoms burst and the flowers shine forth; it is well on the ebb by autumn, bearing on its breast all manner of ripe fruits and seeds, treasures to be cast on the shores of another spring. Each of these tidal periods, one may say, has its characteristic colour: green and gold are the colours of early spring; orange, red, and purple mark the full splendour of summer flowers; and autumn, with its flame-like, often blood-like, withering leaves, rivals all that has

FALLING LEAVES AND EARTHWORMS AT WORK.

gone before. Is it not true to say that the ebb-tide gleams with the glare of burning wrecks ?

Throughout the summer the leaf has lived an intense life, far more intense than we are inclined to give plants credit for, building up with the aid of the sunlight no small quantity of sugar and more complex carbon-compounds, which are laid up in reserve in various parts of the plant. In autumn, however, the vitality is checked ; the movements of the sap become very slight ; and the leaves begin to die. It is partly that they are in some measure worn out by the summer's work, just as the bees are ; it is partly that the outer world has changed. It is well that they should die, lest they begin to undo what they have so well done.

But before they die they surrender to the plant that bears them all the residue of their industry that is worth having. There is a gentle current of sugar and other valuable materials from the dying leaf into the stem before the breath of approaching winter.

The leaf, useful in dying as well as in living, becomes more and more empty of all but waste, and as the retreat of valuable material into winter quarters is being accomplished, there is also preparation for the actual fall. Across the base of the leaf-stalk, in a region which is usually firm and tough, there grows inward a partition of soft juicy cells, actively multiplying and expanding into a springy cushion, which either foists the leaf off, or makes the attachment so delicate that a gust of wind will soon snap the bridge binding the living

and the dead. This is fine surgery, that the scar should be ready before the operation is performed.

Virtually dead the leaves now are, empty houses, all dismantled, with little more than ashes on the hearth. But these ashes—how glorious! for in yellow and orange, in red and purple, in crimson and scarlet, the withering leaves shine forth. They are transfigured in the very article of death, in the low beams of the autumn sun. The yellowness is often due to breaking up of the green colouring matter called chlorophyll; the brighter tints are due to the presence of special pigments, which are by-products or waste-products of the leaf's intense life.

Finally the leaves fall gently from the trees, or, after writhing and rustling in the wind, as if loath to be separated, are violently wrenched off and whirled along the ground. But the tree is not really impoverished by the yearly loss of its leaves, while they, on the other hand, weathered, faded and torn, and mouldered by fungi, are buried by earthworms, to form, with the help of bacteria, the vegetable mould in which are cradled the seedlings of another year.

NUMBER XXVI

SEED-SCATTERING

IN autumn man is harvesting and gathering into barns, but Nature is scattering abroad and sowing. Scattering means rather more than sowing, for it is important that what is sown should be carried away from the shadow of the parent plant or away from a crowded area. It is well that the family should scatter, though there is always the danger that some are lost altogether, and that others are borne into very unsuitable places.

Perhaps the simplest scattering is seen in box-fruits which break up and allow the seeds to tumble out. They may rebound to some distance when they fall, or they may be blown by gusts of wind, or they may be carried by runlets of water. The ants sometimes take the seeds of the cow-wheat into their nests, as if they mistook them for their own offspring, for they are not very unlike cocoons.

But the gentle breaking up of a box-fruit can be improved upon, and there are various degrees of explosive scattering, from the popping of whin-pods and broom-pods, which we often hear when sitting quietly in the country, to the energetic slinging of the balsam. What usually happens is

that the dying of the walls of the dry fruit lets strained parts straighten out. The pulling of the trigger is often due to the state of the weather.

Another simple kind of scattering is seen in a few dry fruits which fix themselves readily to passing animals, such as rabbits, and eventually fall off, it may be far from the site of the parent plant. The little brown nutlets of jack-run-the-hedge or cleavers are covered with roughnesses which take a firm hold; those of the burdock have long crochet-needle-like hooks; and the awns of grasses also fix on very readily and firmly.

Water-birds often carry seeds of water plants from pool to pool on the mud attached to their toes, and there are often seeds inside the clodlets which land-birds get fixed on to their damp feet. Darwin made a thorough study, after his wont, of the fauna and flora of birds' feet, collecting the clodlets and moistening them, to see what would come forth. He proved up to the hilt the importance of this mode of transport, and he was rewarded on one occasion by obtaining from one bird no fewer than eighty germinating seeds.

A third kind of scattering is by means of parachutes, which make it easier for the fruits to be carried by the wind. We see the thistle-down and dandelion-down with their beautiful hairy parachutes "sailing before the wind." It is interesting to watch one enter by the open window of a railway carriage, sail around once or twice, touching the cushions for a moment, and then move on again, finally passing out where it came in. There is

something curiously animal-like in its visit of inspection. An unforgettable sight is a flight of clematis fruits—each a nutlet tipped with a long white feathery plume. It is the hoary appearance of the ripe fruits, massed together on the hedge, that gives the plant one of its common names, Old-Man's-Beard. When the fruits are set free by the breeze,

SCATTERING OF DANDELION-DOWN AND THISTLE-DOWN.
Two small spiders with gossamer parachutes are also seen.

the plumes are often entangled in long rows, which float off with a beautiful undulating motion, like silver serpents in the air.

Another kind of parachute is seen in the winged fruits of the maple and the ash and the elm, and some other trees. In the case of the maple there is a heavy nutlet at one end ; the other is prolonged like an insect's wing. If we throw the fruit into the

air, as every country schoolboy knows well, it sinks slowly down with a beautiful twisting motion at some distance from where we are standing. So, when this fruit is torn from the tree by the wind, the parachute not only acts in a general way like a float, giving the wind time to get a grip of it and whirl it away, but it causes that peculiar twisting fall that even on a quiet day carries it far beyond the tree's shadow. This is all to the good for the seedling.

One of the most effective kinds of scattering is that which seems at first glance to be least propitious—that the fruit should be eaten. What seems, for a moment, like a full stop, works well when it works at all, namely, in cases where the seeds are not digested. Juicy fruits are eaten by many birds and by a few mammals; they are eaten for their own sake, and the hard envelopes of the seeds in the case of berries, the hard stones of the fruit in the case of drupes, save the seed from being digested. It is passed out from the food-canal none the worse, in some cases probably the better, often, naturally enough, far from the place where the fruit was eaten. In this way we can understand the occurrence of an isolated gooseberry bush or fruit-tree far from any human dwelling.

Some of the modes of scattering are peculiar and rare. Thus the squirrel may forget some of his hidden stores of beech-nuts, and germination may take place. There is evidence, too, that earthworms occasionally plant trees. In certain cases the fruit or the seed has some peculiarity which assists lodgment in the soil; thus a long bristle or

awn in the stork's-bill and some grasses begins to twist under the influence of the moisture in the soil, and literally bores its way in. Again, the wall of the seed or the fruit may have a gluey sheath, as in the case of quince and flax, which fixes it to the soil, and also serves to absorb water like a sponge. In the pea-nut the fruit stalk curves down to the ground and pushes the pod in, reminding one in a quaint way of some animal hiding its egg in the ground. Not less effective is the behaviour of the ivy-leaved toad-flax, which beautifies so many old walls. The fruit stalks bend away from the light, and the fruits are actually pressed into the crannies and crevices. That this works well is plain when we notice the rapid spreading of this "mother of thousands," as the plant is sometimes called, over a wall or a cliff which seemed anything but a promising territory to colonize.

Tennyson wrote that of fifty seeds Nature "often brings but one to bear," and he afterwards thought that it might be better to change "fifty" into "myriad." There is no doubt about this, that many of the scattered seeds never come to anything; but what we have been studying shows us that there are many ways in which the scattering works very well indeed.

NUMBER XXVII

AUTUMN FRUITS

IN autumn we see the beginning of the end of many living creatures, but there are also preparations for the winter and for years to come. One autumn evening we sat looking down on the village from the hill above, and, as we watched, all the lights were put out one after another, though sometimes it was simply that the blinds were drawn and the shutters closed; we felt that the day was indeed over; but as we looked longer, there rose in our mind the picture of banked-up fires, of things set in order for the morning, and of other preparations for a new day, besides the chief preparation of rest. It is the same in the household of Nature.

When we turn to fruits, however, we see preparations which are not so much for the individual as for the continuance of the race. In a sense they crown the plant's work for the year, but their full meaning is not for the individual. They protect and scatter the seeds, but all that is in them is loss to the parent plant.

A fruit is the part of the flower that persists after pollination—that is to say, after the possible seeds

or ovules have become real seeds. In most cases a fruit may be described as the ripe seed-box, or as a collection of ripe seed-boxes, with or without extra parts, such as the fleshy top of the flower-stalk or the remains of the calyx. In some cases, as in common cereals, where a single seed fills the seed-box, fruit and seed are almost identical, though the scientific difference remains clear.

In order to understand the different kinds of fruits, we must also notice that the wall of the fruit (the pericarp) often consists of several layers, very different from one another. Thus in the familiar case of a plum there is the firm outside skin (epicarp), which keeps bacteria and moulds out until it gets even a slight wound; there is the fleshy pulp (mesocarp), which is all loss to the parent plant, but attracts the birds, which scatter the seeds; and there is the very hard "stone" (endocarp), which effectively preserves the seed within—a living embryo—from being digested in the bird's food-canal, from being frost-bitten in the ground, from premature sprouting, and from other risks.

The use of the fruit is really to give the seeds a good send-off in life; but this requires looking into. (1) The seed is an embryo plant with a legacy of nutritive material; it grows within the ovule from a microscopic egg-cell fertilized by a pollen-grain; it is, for a time, a very delicate young life. One use of the fruit is to protect the developing seed from bad weather. (2) Even when the seeds are fully formed and have got a good grip of life, there is need for the fruit's protection, for instance, against small

seed-eating animals, such as boring beetles, or against larger creatures, such as birds and rodents, which devour and digest the seeds. (3) Not less important is the part the fruits play in seed-scattering, whether by explosion, or by fixing on to animals, or by forming parachutes, or by being themselves eaten. (4) But even when the seed has been successfully scattered and sown it may require the fruit's protection in the ground. It may not be ready to germinate, or the season for germination may be many months ahead. The enclosing fruit, or its innermost wall in many cases, may protect the seed from the frost and from the appetite of many small animals that work underground.

Kinds of Fruits

Let us think of the different kinds of fruits that we know. First, there are the *box-fruits*, or *capsules*, which are dry in texture and which open in some way to let the seeds out. Poppy-heads and pea-pods are good examples. Second, there are *splitters*, also dry, but *not* liberating the seeds. They break into pieces, each of which encloses a seed. This is true of the fruits of the hemlock and all Umbellifers, of mallows, of Labiates. It is enough to look into the calyx of a ripe white dead nettle to see that the fruit has neatly divided into four nutlet-like pieces, each enclosing a single seed. Third, there are *nuts* and *nutlets* (achenes), also dry and not liberating the contained seed. In true nuts, such as those of the hazel, there is a very hard fruit-wall, to which the enclosed seed is not closely attached; in the

fruits of a buttercup (achenes) the wall is not hard, and the enclosed seed does not adhere to it; in grains of wheat the fruit-wall is somewhat leathery, and the envelope of the seed is closely attached to it.

Turning from the dry to the juicy fruits, we find that there are two main kinds. There are the *stone-fruits*, or *drupes*, with three layers, the middle one more or less juicy, and the innermost one (the "stone") always very hard. Cherries and plums are good examples. Lastly, there are *berry-fruits* in the wide sense, where the seeds are embedded in pulp, as in the case of gooseberry and currant and grape.

Besides these so-called simple fruits, each of which represents one seed-box or ovary, there are more difficult compound fruits, such as a strawberry, which is a collection of tiny nutlets embedded on a fleshy dome at the top of the flower-stalk; or a bramble-fruit, which is a cluster of drupes; or a rose-hip, which is a collection of nutlets inside the fleshy apex of the flower-stalk turned into a cup. There are others, still more compound, which correspond to a whole group of flowers, such as the fig, which is a collection of fruits within a juicy flower-stalk. The pineapple is another familiar example; it seems to be a collection of fleshy berries and fleshy scales.

The True Inwardness of Fruits

It is easier to name fruits than to understand them, but let us think over a few facts. In the case of juicy fruits, we have to remember that the green

plant is a sugar-factory, that it has an income greatly in excess of its expenditure, that it makes very much more sugar than it needs, that some of this surplus overflows in the nectaries of the flowers, and that after the nectaries close up the surplus may be drafted into the fruit. Having got this clearly in our mind, we may go on to say that juicy fruits are well suited for seed-scattering by fruit-eating birds, and that plants with juicy fruits will therefore, in certain conditions, prevail.

Again, in regard to fruits of the box and pod type, which liberate the seeds by splitting, either gently or explosively, we have to remember that the sides of the box are usually the carpels—that is to say, *leaves* set apart and transformed for the production of seeds. These carpels, like other leaves, are organs of a limited length of life; they are likely to die and wither, and crack and shrivel, and fall off like other leaves. Having got this clearly in our mind, we may go on to say that it is very profitable for certain kinds of plants to have box-fruits which open readily to let the seeds out.

Among the valuable food-stuffs that plants manufacture, there are three different kinds which we must know. There are fats and oils, as in nuts; there are sugars and starch (called carbohydrates); and, most complex and valuable of all, there are proteins, such as the gluten in wheat.

Now a big fact about fruits is that they have comparatively little of the more valuable reserve-stuffs. They have comparatively little protein material, but if they are juicy they may have much

water and sugar. Seeds, on the other hand, are rich in proteins, and the advantage of this is plain, when we recognize that what is spent in the fruit is lost, while what is stored in the seeds is legacy. Apart from the seeds, it is said that it requires $1\frac{1}{2}$ lb. of grapes, 2 lb. of strawberries, $2\frac{1}{2}$ lb. of apples, and 4 lb. of pears to furnish as much protein as there is in one egg.

In the ripening of the fruit many interesting chemical changes go on. There are fermentations, for instance, such as that which changes the starch of the unripe fruit into the sugar of the ripe fruit, or that which changes pectose into pectin. There is the appearance of pigments, such as the red of the rosy-cheeked apple, which is the same as the red of the withering leaf and of some flowers. There is also the formation of ethers and oils and some other subtle stuffs, some of which are aromatic, giving the fruit a fragrance which may be even finer than that of the flower.

NUMBER XXVIII

AGAINST THE STREAM

THE river was in high flood, and the salmon were pressing up it. They had been out to sea, and were full of energy ; it was a sight to watch them leaping high into the air over the first step of the salmon ladder, dashing ahead with strong tail-strokes, and rising rapidly to the top of the fall. Their hunger was swallowed up in love, for fishes love—as fishes can. To put it in another way, they were making for the spawning-ground, and they were fasting. It was the fall of the year, and the day was almost wintry, but we did not tire watching the salmon at the fall. It was a sight to be remembered for a lifetime. The lithe body, less silvery than usual, shot out of the water ; then followed a plucky rush amid the bubbles ; then in seven cases out of ten the fish was swept back before it had cleared the second rung of the ladder. It was as exciting as a race. A big strong fellow cleared one barrier after another, lost energy at the last, and was swept back like a log, while another with less dash about him cleared every one, and shot ahead in the swift smooth water above the fall. It was rather pathetic

SALMON LEAPING A FALL.

to see an unsuccessful swimmer swirled back to the foot of the ladder. Like a spent horse, he could no more; but one fancied that he was setting his teeth, so to speak, for the next rush. There was a great crowd that day, for we were able to count fifty-one leaps in one minute, which was hard counting.

As we watched the wonderful sight, we knew, of course, that these salmon, which had grown big and strong in the sea, were obeying an inborn impulse to ascend the rivers till they found suitable places for spawning. They were going back to the place or to the kind of place where they had been hatched from the egg several years before. We knew that the struggle against the strength of the stream was due to urgent impulses in the salmon's body and that the temperature of the water and the amount of oxygen in the water were important outside conditions.

But as we watched, we could not help feeling that these fishes are much more than engines or automatic machines. They are living creatures with a past history that lives within them; they have memories and anticipations, feelings and desires, an inner life like our own in a far-off way. So, at least, it seemed and seems to us.

NUMBER XXIX

SHOWERS OF GOSSAMER

WE read of the Indian conjurer who throws a rope into the air and climbs up it, but we can see spiders actually doing something of this sort. It is especially, though not by any means exclusively, in the autumn that threads of silk may be seen floating in the air, just visible when the sunlight makes them glisten, or entangled in incredible numbers on hedgerows and among the herbage. Sometimes as we walk over the links and stoop down to look along the short grass, we see that it is quivering with myriads of silken lines—the fallen threads of gossamer, sometimes showing rainbow colours in the sunlight.

In most cases the natural history of gossamer is as follows: Young spiders and small spiders of a good many different kinds seem to become restless in the autumn. They mount on the tops of plants, on fences, on the hand-rail of a wooden bridge and the like; they stand on tiptoe with their head facing the gentle currents in the air; they emit from their spinnerets fine separate threads of silk. They stand on tiptoe, but keep firm hold until the threads

of silk floated out on the breeze are sufficient to bear them. Then with a vault they let go, and are borne by the gentle currents often to great distances.

They have no power of directing their movements, but they can add to their parachutes (setting more sail) or coil it up in part (taking in a reef) so that they float farther or sink gently to the earth, as the case may be. When tens of thousands of small spiders do this on some suitable autumn day, we see a flight or shower of gossamer. Some of the spiders —many different kinds indulge in ballooning—are borne far—often, doubtless, too far.

It is interesting that the essential explanation of gossamer was discovered in 1716 by a boy of twelve, Jonathan Edwards, who afterwards became famous in other connexions—as an author, for instance, of a treatise on *The Freedom of the Will.* He saw and figured the "flying spiders," and seems to have clearly understood that the aeronaut was supported by the silk, and that it was borne by currents. "If there be not web more than enough just to counterbalance the gravity of the spider, the spider, together with the web, will hang in equilibrio, neither ascending nor descending otherwise than as the air moves; but if there is so much web that its greater rarity shall more than equal the greater density, they will ascend till the air is so thin that the spider and web together are just of an equal weight with so much air." Which is not amiss for a boy of twelve. Nor is his note on the silk itself: "Seeing that the web, while it is in the spider, is a certain cloudy liquor with which that great bottle

tail of theirs is filled, which immediately, upon its being exposed to the air, turns to a dry substance, and exceedingly rarifies and extends itself."

Dr. H. C. M'Cook, who has contributed so much in a charming way to our knowledge of North American spiders, gives a precise account of the spider's position during the ballooning; and it is interesting to notice, as he points out, that here again the gist of the matter was accurately observed by Master Jonathan Edwards. "As the spiderling vaults upward, by a swift motion the body is turned back downward, the ray of floating threads is separated from the spinnerets and grasped by the feet, which also by deft and rapid movements weave a tiny cradle or net of delicate lines, to which the claws cling. At the same time a second silken filament is ejected and floats out behind, leaving the body of the little voyager balanced on its meshy basket between that and the first filament, which now streams up from the front. Thus our aeronaut's balloon is complete, and she sits or hangs in the middle of it, drifting whither the wind may carry her."

Dr. M'Cook makes a useful suggestion in regard to the shreds and flakes often seen floating or sinking down without any spiders about them. "In many, perhaps in most, cases a number of feints are made before ascent. A spider will take due position and spin out a thread; but it fails to mount aloft. Other unsuccessful attempts follow, each producing a filament. These, while waving to and fro in the eddying air, are often tangled together before they

are whipped off. Others again are united in the air after release."

There are many things about gossamer that are not as yet very clear, but its beauty is beyond dispute. Every alert person who has seen a long stretch of golf-course, or acres of ploughed land, or a piece of moor, or half a mile of hedgerow covered with gossamer, must have admired the sight. The admiration grows when the gossamer is bediamonded with dew or silvered with the frost, or when the sun makes rainbows among it. It is one of the most beautiful things in the world ; and when the threads along the ground sparkle and vibrate, the earth seems to be quivering, like a living thing, as far as the eye can reach. It seems like an emblem of the intricacy of the threads in the web of life. It recalls Goethe's famous words about Nature—"She moves and works above and beneath, working and weaving, an endless motion, birth and death, an infinite ocean, a changeful web, a glowing life."

NUMBER XXX

THE HORNED LIZARDS

IN Mexico, California and Nevada, there are animals called "horned lizards," or Phrynosomes, which are among the quaintest of living creatures. They are often spoken of as "horned roads," the wrong name (for toads are Amphibians and without scales) being probably suggested by their squat shape, their sluggish ways, and their habit of catching insects on a sticky tongue. True lizards they undoubtedly are, but they differ from all others in their flat bodies covered with keeled, spiny scales, and in the circlet of horns upon the head. There are nearly twenty different kinds.

What is the meaning of that circlet of sharp horns on the head, which recall (as if in miniature) the projecting horns of some of the extinct giant reptiles? The shape of head reminds one also of the quaint fruits of the water-chestnut which the peasants round Florence string into most decorative rosaries. But what are the horns for? They serve to ward off blows and bites, for the creature lowers its head and raises the scales of its back when it is on the defensive, and we can well believe that if an enemy bit the head of a horned lizard once, it

would never do so again. The Indians say that if a snake swallows one whole, the unconquerable creature proceeds to work its way by a short cut from the stomach outwards—which must be a very disagreeable process, bringing repentance to the snake.

Another remarkable feature in the horned lizards is their power of colour-change. They have the

PHRYNOSOME—HORNED LIZARD.

secret of the Gyges ring, and putting on the garment of invisibility is for them as easy as winking. "Wherever its home," says Mr. Harold C. Bryant, "the horned lizard resembles the colour of the soil so closely that it is practically invisible except when in motion. Specimens from the white sand of the desert are very light in colour, those from the black lava belt are almost black, whereas those from the many-coloured mountain districts show red and even bluish markings. How quickly a change of surroundings would bring about a change in colour is not definitely known, but some observers say that

the change takes place in from twenty-four to forty-eight hours."

Given horns and scales and the mantle of invisibility, the horned lizards are safe, and we are not surprised to learn that most of the different kinds are represented by large numbers of individuals. We can understand now why they have such a wide geographical range from Canada to southern Mexico, and from the Mississippi to the Pacific coast; why they rarely bite; why they can afford to take things easily, basking in the sun and moving in a most leisurely way. When an enemy comes they "play 'possum"; when they are thoroughly scared they seek refuge in a bush or burrow in the sand.

Even in their burrowing they are unlike most other creatures, for they work their way beneath the ground head foremost. As Mr. Bryant says, "The chisel-shaped head is the principal tool, the legs being used almost solely for forcing the head forward. A wriggling motion of the head and body serves to drive the head beneath the sand and soon covers the body completely with earth. A little shake of the tail flings the dirt over that appendage, and the lizard becomes entirely hidden. The nostrils are kept either at the surface of the ground or near enough to the surface so that breathing is possible." Sometimes the spines are left protruding above the ground like dry thorns.

Stranger even than the circlet of horns and the wonderfully perfect power of colour-change is the habit of "shedding tears of blood." It was for this that the Mexicans called the Phrynosome the

"sacred toad"; it is to this that the boys of San Diego refer when they say they saw the creature "spit blood." As there are very good reasons why it can neither "weep blood" nor "spit blood," what is it that happens? The eyes are tightly shut, the eyelids swell to twice or thrice their normal size, and a fine jet of blood shoots out for several inches from beneath the upper eyelid. The whole thing is startling and quite worthy of the strange creature.

The horned lizards are for the most part insectivorous, catching living ants, beetles, and flies on the end of the viscid tongue. "Why the animal is never bothered by being stung internally by the ants it swallows alive seems hard to explain." It is sensitive enough on the outside; one would expect it to be still more sensitive inside. When insects become scarce, and the cold weather sets in, the horned lizards burrow into the ground and pass into deep winter slumber. If captive specimens are not allowed their sleep they will keep on feeding through the winter, but they are sure to die in the following spring.

We must leave the horned lizards in their winter sleep, though without nearly coming to an end of their peculiarities. One more may be mentioned, which well deserves further study. When a horned lizard is gently rubbed on the top of the head and between the eyes, it turns its head down, closes its eyes, and passes into a stupor, in which it may remain for five or ten minutes. Here we have one of those unsolved problems with which every study in Natural History should begin and also end.

WINTER

NUMBER XXXI

WINTER

EVERY one knows the old season-story of the Sleeping Beauty. She was richly dowered with beauty and other gifts, but all was shadowed by the foreboding of early death. This doom, however, was changed into a kinder spell, which bound her to sleep, but not to dying. All care notwithstanding, the spindle pierced her hand, she fell into deep sleep, whence at last the Prince's kiss served for her awakening. The meaning is plain: The Princess was our fair earth with its glow of life, her youth was summer—often shadowed; the fatal spindle was the piercing cold; the spell-bound sleep was winter's long rest; the kiss that awakened was the first strong sunshine of spring. The old story is one of the "fairy-tales of science."

In the same way, though there is much else in the story, Balder the Beautiful meant the vigour of the sunny summer; and the twig of gloom, the mistletoe, which flourishes and fruits in winter, and was fatal to Balder, was the emblem of the freezing cold which so often brings sudden death or the quiet peace of sleep.

To the cold and the scarcity of food which winter

brings in northern latitudes there is great variety of answer-back on the part of living creatures. Of this variety let us take a few illustrations. Thus most of our birds, emblems of freedom, escape the spell by flight; and, though death is often fleeter still and overtakes them by the way, there can be no doubt that the migration-solution is an effective one.

Other creatures, unequal to the long and adventurous journeys of the birds, retire into winter-quarters, in which they lie low, awaiting happier days. Thus the earth-worms burrow more deeply than ever below the reach of the frost, the lemmings tunnel their winding ways beneath the icy crust of the Tundra, all manner of insects in their pupa-stages lie inert within cocoons or other protective envelopes in sheltered corners, the frogs get into holes or bury themselves deeply in the mud by the side of the pond, and the slow-worms coil up together in their retreats—all trying to get below the deadly grip of the frost's fingers.

Others, again, such as the Arctic fox, the mountain hare, the ermine, the Hudson's Bay lemming, and the ptarmigan, face the dread enchantment of winter, but turn paler and paler under the spell, until they are white as the snow itself—a safety-giving pallor. It is part of their constitution or inborn make-up to change their colour, and the external cold pulls the trigger that sets the process at work. The use of the change of colour is, at least, twofold—the white dress is of service in the chase or in flight, while, on the other hand, it is the

most economical and comfortable dress for a warm-blooded animal when the external temperature is very low.

Man, himself, gets inside other creatures' skins and bids defiance to weather, or, having in his cunning tapped one of the earth's great stores of energy—a coal-bed—sits comfortably by his hearth, gloating in what is really the warmth of a larger sun than that which now sends him in the wintry months too little cheer. Man, too, like the birds, often migrates from the bleak north to a sunnier south, and he knows, like many a creature of less high degree, of winter refuges.

To many living creatures, of high and low degree, the alternative comes—to sleep or die. The spindle cannot be escaped, the cold shall pierce like a sword—but sleep! and it may be well. Of this "sleep" there are, indeed, many degrees, from the mysterious latent-life of frozen seeds and animal germs to the almost equally mysterious true hibernation of marmot and hedgehog. Often, too, it must be admitted that what began as slumber ends by becoming sleep's twin sister, Death.

The great hypnotist lifts his hands, and the sap stands still in the tree, and the song is hushed in the bird's throat; he makes his passes, and growth ceases in bud and seed, in cocoon and egg; he breathes, and sleep falls upon marmot, hamster, and hedgehog, upon tortoise, frog, and fish, upon snail and insect; he commands—his voice is the North Wind—and the water stands in the running brooks, and the very waves of the fiord are still.

Apart from the state of latent life—in which a paste-eel, for instance, may lie neither actively living nor really dead for fourteen long years, and seeds for much longer—there is no form of sleep so near to death as this to which the Wizard of the North commands the true hibernators. The heart of the hibernator beats feebly and somewhat irregularly, the breathing movements are at long intervals and very sluggish, the food-canal is empty, income is (apart from oxygen) at zero, and expenditure is but little more. The fat, accumulated in days of plenty, is slowly burnt away, sustaining in some measure the animal heat. In the hibernating mammal the power of keeping an almost constant body-temperature has broken down for a time, and the body cools greatly; the sleeper will hardly answer back to anything, even to a cold bath; the creature steadily loses weight. The real wonder is that it keeps alive. In most cases its safety depends on getting into some snug retreat or well-blanketed confined space, to the temperature of which its own body-temperature approximates. In an exposed situation the sleeper would die.

The general meaning of winter-sleep is in most cases plain. Life saves itself by ceasing to struggle, by retiring within its entrenchments. Death is baffled by a deep device, in which activity practically ceases without life itself being surrendered. Hibernation is the finest illustration of the value of "lying low and saying nothing."

Yet there are other aspects of the winter's sleep. To some it is a time of repair—a long night—after

DORMICE.

the fatigue of a long day. Quite apart from the weather, it is good that the queen humble-bee should sleep through the winter, just as it is well for the fisherman that he should loaf after the storm.

To others the sleep is in some measure a preparation for a new day. Thus in the seeds which slumber in the earth, each a young life, there is a rotting away of the husks which the delicate embryo could scarce burst, and later on there are processes of fermentation, by which the legacy of hard, condensed food-material is made available for the young plant. Similarly, within the cocoons there lie the chrysalids, quaintly mummy-like and inert to all appearance, but slowly undergoing that marvellous change, the result of which is the winged butterfly of next summer's sunshine.

NUMBER XXXII

STORING FOR HARD TIMES

THERE are many different ways in which animals meet the winter. Many go into winter quarters, and, reducing their expenditure to a minimum, lie low till the spring calls them again to action. Others, like the wolves, continue to live dangerously, simply sharpening their wits and increasing the keenness of their hunting. Some, like the ermine and the ptarmigan, don a white dress, which is both safe and comfortable. Others solve the problem by a change of habitat—notably the migratory birds. There are several other solutions of the problem, and one of these is to lay up stores, to hoard, to save. Many animals do this inside their bodies, but let us keep to external savings.

A beginning of storing may be looked for, perhaps, in activities like those of earthworms, which collect leaves and drag them down into their burrows, at once making these more comfortable and providing a supply of food for the rainy day. It is surely the acquisitive habit that they have, these earthworms, for we got more than fourscore leaflets from one

burrow, and we have often seen feathers as well as leaves being taken underground.

Among insects, we find an inclined plane of storing activities that leads up to the climax illustrated by hive-bees and by some of the ants. Many visitors to the Mediterranean region have admired the industry of the scarabees, who roll marble-sized balls of dung to their holes, and there gnaw at them continuously till all is consumed. In this there is, indeed, only the first stage of storing, but the late M. Henri Fabre described in his inimitable way how the mother scarabee moulds a pear-shaped mass and lays at the narrow end an egg which occupies a special hatching chamber and has beside it a special first meal for the emerging grub! Here it is not difficult to imagine the step from collecting for self to collecting for others, and it is interesting to know that in some of the dung-beetles the mother lives on to see her family hatch out, which is very rarely the case among the higher insects that store food around their laid eggs.

Among the solitary bees the mother makes a store for the brood which she never survives to see; among humble-bees the store is begun by the mother but continued by her worker-children, and in some kinds at least a part of the society survives the winter: in some tropical bees there are permanent societies but imperfect combs; in the hive-bees there are permanent societies and perfect combs. The elaborate storing of hive-bees, carried to such perfection under man's care, is, to begin with, conneted with surviving the winter—*i.e.* with per-

THE SQUIRREL HIDING NUTS.

manence, and with the survival of the mothers after their offspring grow up, *i.e.* with the possibility of social tradition.

It is impossible to think of storing without a vision of Solomon's ant "which, having no guide, overseer, or ruler, provideth her meat in the summer, and gathereth her food in the harvest." And, as among bees, we find all grades among ants from those that do not store at all to those that make a fine art of it. According to recent studies of the common Mediterranean harvesting ant, the seeds which are collected are kept for a time dry and are eventually put out in the rain so that they begin to germinate. This has the advantage of bursting the hard seed-coats, and in some cases of starting processes of fermentation. At a certain stage, however, the ants kill the embryo-plant by biting at it, and the seeds are dried again in the sun. The dried seeds, of some clover-like plants for instance, are then taken back into the nest and chewed into dough. This is dried once again in the sun in the form of little biscuits, which are eventually put into the cupboard. It is likely that different kinds of seeds receive different treatment, and in some cases it seems that the stored material is not eaten after all, but is used as a culture for moulds of which the ants are very fond. It is a very interesting fact that the use of moulds—reminding us of man's mushroom beds—is practised by a number of quite unrelated animals—namely, by certain ants, termites, beetles, and mites.

Among backboned animals it is difficult to find

convincing instances of storing until we come to birds and mammals. Apart from the numerous birds that store food in their crops, sometimes so exuberantly that they cannot fly, there are some that may be said to lay up nutritive savings outside of themselves. The large eagle owl, which occasionally visits Britain, often gathers a huge quantity of food (including hares and rabbits, poultry and pigeons) for his mate and offspring; and peasants have been known to utilize him as Elijah his ravens. There is an old tale that ptarmigan make stores of buds and berries beneath the snow, but there is no doubt that at least two species of woodpeckers store acorns, sticking them firmly into holes which are bored "for the purpose" in the tree stems. This is all the more interesting if it be true that what the woodpeckers really eat is not the acorn but a kind of grub that develops inside it.

Not a few mammals are in the habit of hiding away surplus food, and it is easy to imagine how this might lead on to a more definite storing instinct such as squirrels show. In a number of different hoards the squirrel hides hazel-nuts, beech-nuts, and acorns, and these may be a stand-by in the hard times of winter when the beautiful creature, who is not a true winter-sleeper, is unable to sleep away its hunger, or when the young ones, who remain for a long time in the company of their parents, plead for food. In some mild parts of the country the squirrel's storing instinct seems to remain undeveloped. There are other mammals, such as the marmots, who make their burrows comfortable with

grass and shut the door when winter knocks ; it is again easy to see that this might lead on to a hoarding of food supplies. Such hoarding is well illustrated by some of the light sleepers, such as dormice, who awaken whenever the weather is mild and are then inclined to have something to eat. In the burrow of the hamster several store-chambers are made, and grain, as well as hay, is accumulated in considerable quantity. The little snow mouse, that thrives all the year round at a high altitude on the Alps, makes stores of chopped grass and gentian roots. There are many other examples of storing, but we have given illustrations enough to show that the thrifty habit has taken firm hold in many different corners of the Animal Kingdom.

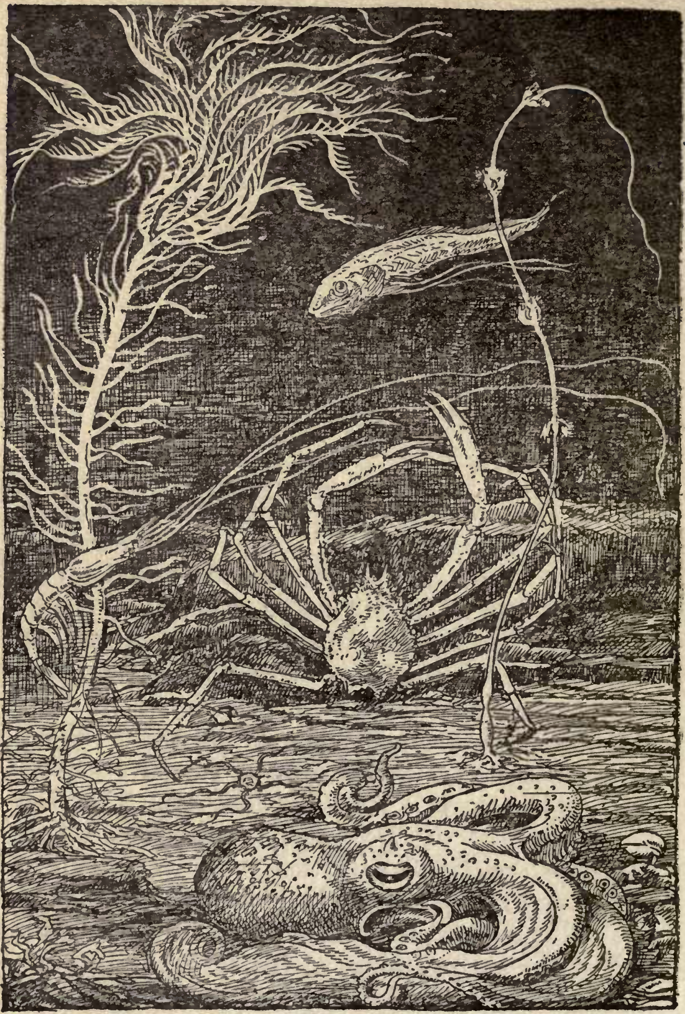
NUMBER XXXIII

THE DEEP SEA

THERE are six great haunts of life—the shore, the open sea, the deep sea, the fresh waters, the dry land, and the air. Every one has seen more or less of the other haunts of life, but no one has had any vision of the Deep Sea—the abyssal region beyond the light limit and the plant limit. Many have been within a stone's throw, or stone's drop rather, of it; a few have had the rare experience of dredging from its distant floor; many have examined Deep-Sea animals in museums; but no one has ever seen its secrets in their natural setting, and, we suppose, no one ever will.

Depth.—The average depth of the sea is about $2\frac{1}{2}$ miles, and over 80 per cent. of the sea-floor lies at a depth of over a thousand fathoms. Thus the greater part of the Deep Sea is *very deep*. It is, indeed, a remarkable fact that the great Deep Sea plain, deeper than 1,700 fathoms, extends over about 100 millions of square miles, which is more than a half of the entire surface of the earth.

Here and there in the Deep Sea there are tremendous depths, technically called "deeps," of over 3,000 fathoms; and eight soundings of over 5,000 fathoms



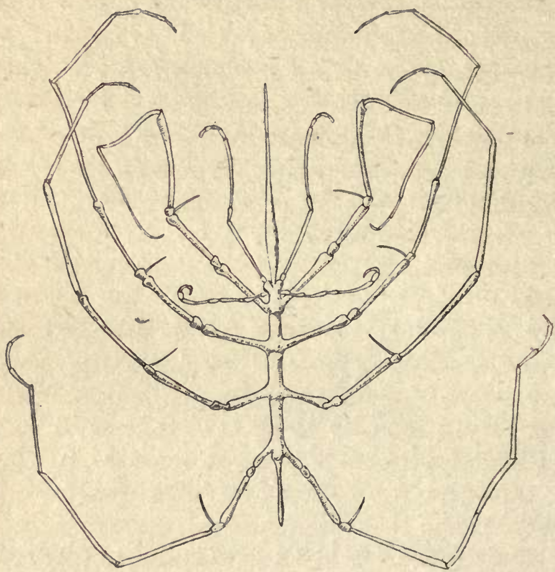
A corner of the Deep Sea, showing Cuttlefish, Crab, Prawn with very long feelers, Feather Stars, a filamentous relative of the Sea-pen, and a Fish.

have now been taken. Among these is the famous "Challenger deep" in the north-west Pacific, of 5,269 fathoms, nearly six miles, in which Mount Everest would be more than engulfed. In fact, its summit would be 2,600 feet below the surface. Another instance is the "Swire deep," off Mindanao, of 5,348 fathoms, over six miles, in which Mount Everest might be submerged with 3,087 feet to spare.

Pressure.—Great depth means a great weight of water; it follows that there must be enormous pressure in the Deep Sea. At 2,500 fathoms it is 2½ tons on the square inch, perhaps twenty-five times as much as the pressure in the cylinder of an average railway locomotive. Even the water is compressed, and bodies into which the water cannot penetrate quickly enough are squeezed almost beyond recognition when they are sunk to great depths. The *Challenger* explorers found that a piece of wood sunk to the abysses was so heavy when pulled up again that it sank in water. The muscles of a dead animal, such as a whale, must undergo a tremendous compression if the carcass sinks.

Temperature.—The sun's heat is lost at about 150 fathoms, and the Deep Sea is therefore intensely cold. With relatively little change (two or three degrees in the course of the year) the temperature remains near the freezing-point of fresh water (32° Fahr.). The bottom temperature may be below 30° Fahr. in Polar waters, and over the greater part of the whole sea-floor an eternal winter reigns. What a contrast this is to the changefulness of the

surface of the sea and of the dry land! The coldness of the deep water seems to be mainly due to a flow of cold bottom-water from the Southern and Antarctic Oceans towards the equator, and in a less degree to a similar flow from the sub-Arctic region.



Deep-Sea Pycnogonid or "Sea-Spider," Pipetta, with extraordinary length of limb in proportion to the size of the body. The males carry the eggs. (*After* Loman.)

Darkness.—There is very little penetration of light beyond 250 fathoms, so that the world of the Deep Sea is in utter darkness, save only in so far as that is relieved by gleams of "phosphorescent"

light. In some places where there is much of this luminescence, it may be that the scene is like the ill-lighted suburbs of a town on a very dark night, or like a moorland with no light save from the stars.

Calm and Silence.—Another physical feature is the pervading calm, for the severest storms are shallow in their grip, and though the cold polar water is ever creeping along the bottom towards the equator, this is a relatively slow movement. Only in a few places is there evidence of what may be called a current. If there were rapid movement the deep ooze which covers vast areas of the sea-floor would be raised in whirling clouds. Thus we must think of the deep sea as extraordinarily still and quiet, for there can be no noise to break the abiding silence of the abysses.

Monotony.—There is some variety in the composition of the sea-floor, for the remains of lime-shelled creatures are abundant in some places and of flint-shelled creatures in others, and the debris called "red clay" is found in the deepest parts of all. But otherwise monotony prevails. There is no scenery, except that here and there a ridge stretches like a watershed, or a volcanic cone rises abruptly to the surface, or a great depression leads into one of the "deeps." Otherwise there are great stretches of undulating plain, like very flat sand-dunes, or like a great desert. There is no sound and echo, no day and night, no summer and winter in the monotonous Deep Sea. It is all silence, all night, all winter. Apart from the animals altogether, what a remarkable picture rises in the mind—a

picture of the for ever unseen—a strange, dark, cold, calm, silent, monotonous world!

No depth too deep for Life.—It was proved by the *Challenger* expedition that there is practically no depth-limit to the distribution of animal life. Wherever the long arm of the dredge has been able to reach, there are organisms and plenty of them. It is astonishing to read of Sir John Murray and Dr. Hjort using an otter *trawl*, with fifty feet of spread, at a depth of 2,820 fathoms (over three miles), and using it very successfully. It should be noticed that there are some thinly peopled areas—sea-floor deserts, so to speak; that there is a richer population at the more moderate depths; that there are more animals on the calcareous ooze than elsewhere; and that there are probably thinly-peopled zones between the bottom and the light-limit. But the big fact is that there is no "deep" too deep for life.

Plantless.—Another big fact is that, beyond the sunk resting stages of some simple Algæ, there are no plants in the Deep Sea. This follows from the absence of light, and it involves as a consequence that all the Deep-Sea animals must be either carnivorous or devourers of debris. There are the usual "nutritive chains"—Deep-Sea fish eating Deep-Sea crustacean, and that eating worm, and that eating still smaller fry; but since they cannot all be eating one another there must be some extraneous food-supply. That is found in the gentle and ceaseless rain of small creatures, killed by changes in the open-sea meadows overhead, and sinking through

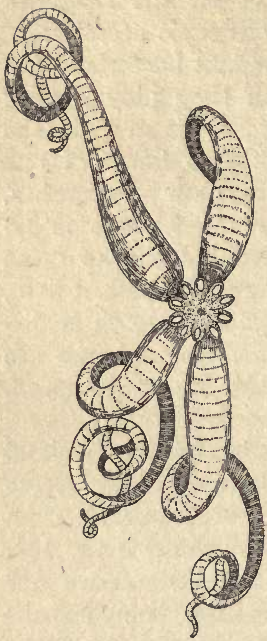
the miles of water like snowflakes falling on a very still day. While big corpses like those of fishes are doubtless all to the good if they reach the bottom undevoured, what counts most for the Deep-Sea food-supply is the rain of microscopic atomies.

No Bacteria.—There are abundant bacteria in the sea, in the economy of which they play a very important rôle, but there seem to be none in the great abysses. It is interesting to know of one place in the wide world where there are no microbes. From their absence it follows that there is no rottenness; everything is devoured in the great clearing-house. The whale's carcass is picked bare, by crustaceans in particular; the skeleton is dissolved away till only the stone-like ear-bones are left. Of the great shark everything soon disappears save the teeth.

Many different kinds of Animals.—The animal population of the Deep-Sea floor includes representatives of most of the classes of animals from Protozoa to Fishes. Let us run through the list. There are many kinds of Foraminifera and a few Radiolarians (not including, of course, the sunk shells of surface forms of both); there are many flinty sponges, but no limy ones; there are sea-anemones and some related corals; many worms burrow in the ooze; there are numerous star-fishes, brittle-stars, sea-urchins, sea-cucumbers, and very graceful sea-lilies swaying on their stalks like daffodils by the lake-side; crustaceans of high and low degree abound; and there are quaint sea-spiders which are neither spiders nor crustaceans; most of the

molluscan types are abundant ; and finally there is a weird army of voracious fishes.

Fitnesses.—A common feature in the fixed Deep-Sea animals is the possession of long stalks on which the body is raised high out of the treacherous ooze. A similar fitness is seen in the extraordinarily long limbs which many of the crustaceans and sea-spiders exhibit. They illustrate an extreme of lankiness and they may be thought of as walking on stilts. In many cases the limbs are several times longer than the body. There can be little doubt that these elongated limbs are suitable for moving delicately on the soft surface. Some of the Deep-Sea brittle-stars show long arms as compared with shallow water forms. The extraordinary elongation of limbs and other parts would be impossible except in perfect calm.



Deep-Sea Brittle Star or Ophiuroid, Astrocharis virgo, showing the disproportionate elongation of the arms—very liable to breakage—and the very small central disc. (*After* Koehler.)

Many Deep-Sea animals are very delicately built,

with water through and through their bodies. A delicate structure like Venus's flower-basket (Euplectella), which is shivered in a child's fingers, lives in depths where there are tons of pressure on the square inch. The whole body is open to the water and the pressure is not felt. For while a hermetically sealed glass vessel is crushed in when it is lowered into deep water, an open glass vessel, no matter how delicate, is not affected. On the *Challenger* expedition, Mr. J. Y. Buchanan made an instructive experiment which has been often cited, He took a hermetically sealed empty glass cylinder. wrapped it up in flannel, enclosed it in a copper cylinder with perforated ends, and lowered it to 2,000 fathoms. At a certain depth the glass cylinder was shivered into snowy powder, for its walls could not withstand the increasing outside pressure of the water. The shivering took place so suddenly that before water could rush in to fill the vacant space, one side of the copper cylinder caved in. As Prof. Wyville Thomson said, an "implosion," not an explosion, occurred.

When a Deep-Sea fish rising suddenly gets into a zone of much reduced pressure, the gas in its swim-bladder, which had its pressure adjusted to the greater depth, expands, and the fish, in spite of itself, is hurried to the surface, "tumbling upwards," as Professor Hickson puts it. The transition is too rapid for a readjustment to be made.

Another fitness at once intelligible is the fine display of touch organs, as is natural enough in a world of darkness. There may be feelers longer

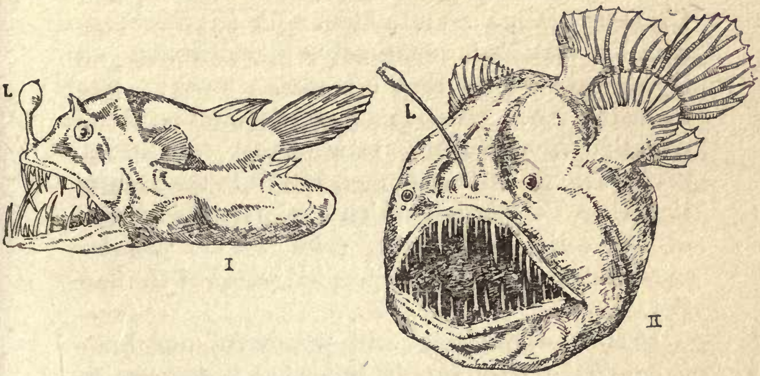
than the whole body, probing a long distance ahead, so that the animal gropes its way as a blind man does with his stick. Many of the long legs of crustaceans bear tactile bristles, and many of the fishes have long slender and sensitive barbules stretching backwards from the chin or from the fins.

Problems.—There are many unsolved problems in the Deep Sea, and one of these is the frequent "phosphorescence." It is seen in animals of high and low degree; it is exhibited by fixed animals and by free swimmers; it is produced by a great variety of organs; and these are sometimes situated on most extraordinary places—near the end of the tail, on the tip of a long flexible rod, inside the gill-chamber of a crustacean. It is so common that it surely has some meaning.

May it be sometimes a lure, attracting victims, who come like moths to the candle? Is it sometimes an advertisement on the part of unpalatable creatures, warning off intruders and molesters, as the rattlesnake does with its rattle? Does it sometimes serve as a lantern, guiding the active animal to its prey? Of course that would not apply to cases where the light is at the hind end! Does it serve in some cases as a "recognition mark," enabling those of the same kin to know one another? The light-production of Deep-Sea animals is still in great part an unsolved problem.

Another difficulty is raised by the fact that there is so much colour in Deep-Sea animals. What can be the use of that in an abode of darkness? There

are many reds, *e.g.* in Crustaceans and Anemones; there are shades of orange and yellow; there are some instances of beautiful blue; there is almost no green. It is noteworthy that there is very little in the way of spots or stripes, most of the animals being all one colour. Perhaps the Deep-Sea colours are like those in withering leaves—without utility in themselves.



Two Deep-Sea Fishes. L, Luminous organ.

Another problem—the most general of all—is raised by the fact that many Deep-Sea animals are quite closely related to shore animals, with essentially the same activities discharged by similar organs, and yet under such different conditions of temperature and pressure. Processes of digestion, for instance, which go on in shore animals in the warmth of the Tropics, are also going on on the floor of the Deep Sea at a temperature near the freezing-point of fresh water.

Origin.—As to the origin of the Deep-Sea animals, the evidence points to the conclusion that the abysses have been persistently colonized age after age by migrants from the shore and from the "Mud-Line." There is a marked resemblance between certain representatives of the Deep-Sea fauna in a given region and certain representatives of the nearest shore fauna.

The Wonder of the Deep Sea.—A knowledge of the Deep Sea has cut into human life ; it has been *of value to mankind*, practically, in connexion with laying cables (and that has meant much) ; intellectually, for it has been an exercise-ground for the scientific investigator ; emotionally, for there is perhaps no more striking modern gift to the imagination than the picture which explorers have given of the eerie, cold, dark, calm, silent, plantless, monotonous, but thickly peopled world of the Deep Sea.

Useful, stimulating, and wonderful our knowledge of the Deep Sea is, but what is the significance of the facts ? We must try to realize that the Deep Sea is an integral part of a larger whole. Just as the making of the great " deeps " was connected with the raising of great mountains, so the abyssal fauna is wrapped up with the whole vital economy of the Earth. For it is the overflow basin of the great fountain of life whose arch is sunlit. It is necessary to the wholesomeness of the ocean. It is the universal clearing-house.

Perhaps we go a little deeper still when we recognize that life, which will not be gainsaid, has

conquered the abyssal desert, that this by-way is full of living creatures which will scarcely be baffled by any difficulties. They have conquered the desert of the great deeps ; they have peopled the floor of the sea with forms just as beautiful and fit and healthy as we find anywhere else. Animate Nature is like the embodiment of a thought.

NUMBER XXXIV

A PECULIAR PEOPLE

THE story goes that a lady seeing penguins for the first time, and that, as it happened, in the sea-lions' enclosure at the Zoo, remarked that it was strange that the young seals were so like birds. She might well be excused for an error that showed an open mind, for quainter creatures than penguins it would be hard to imagine. They are extraordinary in their attitudes, now upright like sentinels and again grovelling on the ice like reptiles; in their varied movements, gambolling like porpoises, swimming like ducks, diving with the help of their flippers to a depth of ten fathoms, toddling on the ice like top-heavy babies, and tobogganing in a manner all their own; in their daring surrender of wings in exchange for flippers; in their way of moulting their feathers in great patches. But it is when we inquire into their habits that the most striking peculiarities are discovered, and here we owe much to Staff-Surgeon Murray Levick, of the *Terra Nova* (1910) Antarctic Expedition, who has got nearer the heart of the penguin—of the Adélie Penguin at least—than any previous observer.

ADELIE PENGUINS.

Dr. Levick tells us that towards the middle of October, a single Adélie penguin was seen on the rookery at Cape Adare in the Far South. Two days afterwards there were two, and next day about a score, and next day "as we looked across the sea-ice to the northwards, we could see a long line of Adélies approaching, tailing out in snake-like fashion, as far as the horizon." This is the first picture, the return of the penguins to their birth-place, for some at least return to the same rookeries year after year to breed. We are out of our depth at once when we think of the mysterious homesickness that brings these flightless birds back to their cradle over hundreds of miles of trackless sea. When they get agoing on the ice they toddle hurriedly, one hundred and thirty steps per minute, six inches at a step, two-thirds of a mile per hour. "In the still air their little wheezy respiration could be heard distinctly, and they seemed to be somewhat out of breath." Every now and then they suddenly flop forwards on their breasts and take to tobogganing at the same rate as before, using their legs as propellers. By the end of the month the rookery at Cape Adare was crowded with some three-quarters of a million birds.

The hens take possession of the old stone-nests or scoop out new hollows in the ground, and wait. The cocks are very drowsy at first, but by and by they take to fighting. The combatants lean their breasts against one another and rain in blows with their flippers. In many cases blood is drawn, but Dr. Levick never saw a fatal encounter.

The nests are made of rounded stones which the cock collects, stealing them when he can. Jagged pieces of quartz seem to be much prized, and there was an eager demand for Dr. Levick's painted pebbles, red being preferred to green. It is characteristic of the Adélie penguins to climb heights and nest on cliffs. Some of them, coming straight from the sea, make at once for the heights, and climb laboriously from ledge to ledge. Dr. Levick found a colony at the very top, about 700 feet above the sea, a site which involves prodigious toil. For during the whole of the time when they are rearing their young, these mountaineers had to make several journeys every day carrying quantities of food for the young ones, each journey meaning about two hours' stiff climbing.

Not until the eggs have been laid does either parent go to feed. Then one of them goes off to the water and stays away in many cases for seven to ten days, after which it returns and gives the other its leave. The shortest period of total abstinence from food is about eighteen days, and the longest about twenty-eight days—a good instance of the parental sacrifice so characteristic of many of the higher animals. When the chicks are hatched, the parents relieve one another at frequent intervals, and their shape, always quaint, becomes grotesque when they return so heavily laden with crustaceans that they have to lean back to keep their balance. They carry the crustaceans in their food-canal, and sometimes they try to carry so much that they lose it all. The chicks feed, as young cormorants do,

by thrusting their head into their parent's gullet. When the hen is sitting, nothing, not even a wrangle with her next-door neighbour, will induce her to move until her turn comes ; but the cocks are easily led astray by their combativeness, and often do much harm in the crowded rookery in spite of the protests of adjacent birds who are seen trying to make peace.

A pretty incident was seen one day—a cock penguin bringing a lump of snow for the hen to eat. "The cock, when away from his mate, evidently had in his mind the fact of his hen being thirsty and unable to get snow as he could."

In the water the Adélie penguin has but one enemy, the voracious sea-leopard, which sometimes swallows it whole. The sea-leopards often lurk below the ledge from which the penguins dive, and Dr. Levick gives us a glimpse of another side of penguin nature when he tells of the tricks the birds play to get one of their number to be the first to go into the water. Apart from the sea-leopards, man, and one another, the adult penguins live at peace, but terrible damage is often done at thaw-time by falling boulders and land-slides. Sometimes, too, crowds of nesting birds are buried in snow-drifts, which are especially serious when they freeze on the surface. But even then the tough creatures can survive for many weeks within little chambers thawed by the warmth of their bodies, and provided with breathing-holes through which they thrust their heads. On the whole, the full-grown birds are very safe, but among the eggs and the young the mortality is

high, for which the robber-gulls or skuas and the reckless combats of the penguin-cocks are largely to blame.

There is a lighter side to the life of the penguins, for they show a taste for certain simple games which they play on the sea-ice on their way to and from their bath. There is the diving, in which the succession is so rapid "as to have the appearance of a lot of shot poured out of a bottle into the water"; there is the "porpoising," the leaping out of the water, and the game of "touch last" on the sea-ice. A favourite play was to board an ice-floe till it would hold no more, and get carried by the tide to the lower end of the rookery, where every bird would suddenly jump off and swim back against the stream to catch a fresh floe and get another ride down. To find the time for all this fun without leaving the chicks to perish, a strange arrangement has been devised. The parents pool their children in groups which are left in charge of a few conscientious persons who ward off the skuas and keep, or try to keep, the chicks from straying. The holidaying parents bring food at intervals, when their conscience smites them. On the whole, the Adélie's lot appears to be a happy one, and we read with pleasure of the "ecstatic" attitude which they assume, and the weird "song of satisfaction" which they utter when all is well with their world.

One other picture is surely unique in the annals of natural history. It was a sort of drilling on the ice, a congregating of thousands, and the execution of ordered movements for hours on end. Dr.

Levick's interpretation is probably correct, that although what he saw was not directly connected with migration, it may be a sort of reminiscence of a bygone habit of massing together in large numbers before the autumnal journey northwards. The journey is, of course, still undertaken, but little is known of it, for the winter quarters of the Adélie penguins after they leave the Antarctic shores are wrapped in blizzard and mist, though they probably lie near the northernmost limit of the pack-ice in the far southern seas.

NUMBER XXXV

THE STRUGGLE FOR EXISTENCE

THIS phrase—the struggle for existence—was used by the greatest of naturalists, Charles Darwin, to include all the answers back that living creatures make to the difficulties that beset them. It means not only keen competition for food and foothold, but all sorts of endeavours after well-being ; it means not only efforts for self, but efforts which secure the safety and prosperity of the young ones.

In the case of man, it means that when Nature has said to him, "You must die," he has always answered back, "I will live." It means that he has fought with wild beasts and worsted them or tamed them, that he has sifted out the wholesome from the poisonous plants, that, cowering and crouching for ages but never giving in, he has watched the forces of nature until he has mastered their secrets, that he has been to his fellow-men since the beginning a strange mixture of selfishness and sympathy, that he has kept up an age-long endeavour after well-being—always at his best when rowing hard against the stream.

Among living creatures we see three different forms of the struggle: between fellows, between foes, and with fate. When the locusts of a huge swarm have eaten up every green thing, they sometimes turn on one another. This cannibalism among fellows of the same kith and kin is seen also among many fishes; it is the most intense and also the ugliest form of the struggle for existence. An eerie example of it—cannibalism in the cradle—occurs among the young of the great whelk or roaring buckie within their egg-cases, which are often thrown up in great bunches on the seashore, and also in the vase-like egg-cases of the common dog whelk, which are fastened to the rocks. The same sort of struggle is seen between thick-sown seedlings of the same kind, which compete with one another for room and food and light. In his *Woodman*, Robert Louis Stevenson speaks of the warfare in the dense tropical forest where the silent foes "grapple and smother, strain and clasp," but neither among plants nor among animals need the struggle be direct—the whole point is that the competitors seek after the same things of which there is but a limited supply. Whether a full-grown frog eats a tadpole of its own kind, or coral polyps compete silently for the same niche among the rocks, or the rabbits for the scarce grass on the dunes, the general fact is the same in all cases, and, apart from chance, the result will be the same: the survival of those fittest for the particular conditions of life. The struggle may be for food, or foothold, or breathing-space, or what is sought after may be some

luxury, as is seen in the wild stampede of the reindeer when the longing to visit the salt seashore becomes irresistible—many are overthrown and trampled in the mad rush. We must include here the battles of the stags and the tournaments of the blackcock at sunrise on the hills.

But the struggle for existence is also between foes of quite different kinds. We see it between carnivores and herbivores, between birds of prey and small mammals, between wasps and quieter insects. There is sometimes a stand-up fight, for instance between wolf and stag, or between hawk and ermine. But sometimes the fight is all on one side, for the stupid little guinea-pig-like lemmings which go on the march when they are overcrowded and when food has become scarce in the Scandinavian valleys, can offer almost no resistance to the birds of prey and beasts of prey which follow them and thin their ranks.

Moreover, the competition between different kinds of creatures need not be very direct; it is enough if both kinds seek after the same things of which there is a limited supply. The victory will be with the strongest and most efficient, or it may be with those that multiply most rapidly. There is a very real, though mainly indirect, struggle between coarse and finer grasses which are spreading in the same bare stretch of ground—for instance after a fire in the South African veldt, or between the bracken and the grass, even between the bracken and the heather, on the Highland hills.

But the true picture of the struggle for existence

must pass beyond the idea of competition altogether, to cases where the living creature has to gird up its loins in some way against the difficulties of its physical surroundings. This may be called the struggle with Fate, and it is illustrated between birds and the winter's cold, between aquatic animals and changes in the water, between plants and drought, between plants and frost. So we see that the "struggle for existence" is wider than is suggested by the words taken literally. It includes all the answers back that living creatures make to the difficulties that beset them. "Behold the life of ease, it drifts; the sharpened life commands its course": that is the idea of the struggle for existence. There is an extraordinary abundance of life, but the forces of nature and the changes of nature are quite careless of it; the river of life is always tending to overflow its banks, and there may be more mouths to fill than there is food to fill them with; love calls and hunger calls and there is often no satisfaction; there are many risks in the life-history of falling through holes in the Mirza bridge which all living creatures have to cross; the living creature has a will of its own—a will to live. All this, and more, is condensed in the three words "struggle for existence."

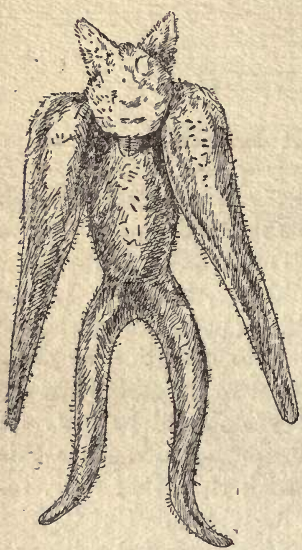
NUMBER XXXVI

A LIMB FOR A LIFE

OF all the ways in which animals escape from tight corners, is there one more daring than the surrender of a part which often saves the whole? Seemingly daring, one should say, however, for all the ordinary cases of surrendering parts are nowadays quite apart from any deliberate intention or clear awareness that it is better that one member should perish than that the whole life should be lost. A starfish, seized by one of its arms, surrenders this to the captor and escapes with the other four, re-growing the missing part at its leisure. But it does not think over its sacrifice of a limb for a life, or make up its mind that it is worth while. It is nowadays part of the inborn make-up of the starfish to behave in this particular way.

The highest level at which surrender of parts is practised is among lizards, many of which need but little provocation to induce them to surrender their tail to their assailant—an expedient that often saves their life. The British limbless lizard or slow-worm has an almost uncanny readiness in surrendering the tail of its snake-like body. That lizards have

taken ages to bring their life-saving curtailment to perfection seems probable, especially when we notice that in many cases there is a special breakage plane, a weak line going through the whole tail, including the backbone. What is lost can be regrown at leisure, though not with the original finish. Newts and salamanders (and the tadpoles of frogs and toads) have great powers of regrowing parts that have been bitten off, but, so far as we know, lizards are the only backboned animals that show surrender of parts. Among backboneless animals, however, it occurs often. We find it, for instance, among sea-slugs and other Molluscs, and in many different kind of worms. In the Palolo worm, which burrows in the coral-reefs, nearly the whole of the body is broken off at the breeding season and bursts in the water, liberating tens of thousands of germ cells, while the head remains in the rock and makes a new body by and by. Among starfishes, brittle-stars, feather-stars, and sea-



Common Starfish (*Asterias rubens*) regenerating lost parts. It shows at the top two arms which are just beginning to be regrown. Below we see that the largest of the five arms has been previously regrown double. (*After M'Intosh.*)

cucumbers there is an extraordinary prevalence of the surrender of parts. A starfish may jerk off each of its five arms seized in succession; it may cast off an injured arm; in rare cases there is multiplication by division. Sea-cucumbers discharge their insides in the spasms of capture and may thus escape from an astonished foe. The replace-

THE SHORE-CRAB THROWING OFF A DAMAGED GREAT CLAW.

ment of the food-canal is sometimes accomplished in ten days, though it may take as many weeks. The heart-urchin often gives off its snapping spines when they nip the skin of some molester.

One often sees among the stubble very interesting somewhat spider-like creatures called harvestmen (Phalangidæ), which move swiftly (in the evening

especially) on extraordinary lank legs, over twenty times the length of the body. They hunt mostly by night, killing and sucking small insects and drinking drops of dew. If we catch one by the leg it surrenders it instantaneously and stalks away. The same sort of profitable surrender is exhibited by some spiders and by some insects, such as grasshoppers, crickets, and their relatives.

The surrender of limbs is very common among crabs and other Crustaceans. When the limb is seized or when it is damaged by the fall of a stone what does the crab do but break it off near the base? There is a particular line of weakness—the breakage plane; the surrender is brought about by the very forcible contraction of the muscles at the base of the limb; and the snap is over before we have time to say "a limb for a life." Neatest of all is an arrangement inside the base of the leg, just below the breaking-line, whereby a bandaging membrane with two flaps closes up the wound and prevents bleeding. This is wonderful surgery, to cut and to bind at the same moment. We are reminded of the partition which in autumn grows across the place where the leaf-stalk joins the branch, and closes up the wound as it separates off the withering and dying leaf. Inside the crab's bandaging membrane a new leg is formed in miniature, and after a time when the crab moults its husk this new leg shoots out like a Jack-in-the-box, and soon hardens.

So we see that among many different kinds of animals the device has been established of surrendering a limb and saving a life. In some way or other

many have learned the lesson that it is better that one member should perish than that the whole life should be lost. But, however the lesson was learned, and we may be sure that it was not by thinking over the matter, it has now become engrained in the constitution of the race.

NUMBER XXXVII

STRUGGLE AND MUTUAL AID

LIFE is an endeavour; it expands, it intrudes itself, it protests against limitations. One living creature presses upon another, competes with another, eats another. And for all this thrust and parry between living creatures and the difficulties that surround them we use the formula "struggle for existence." Surely Darwin had this broad view in mind when he wrote the strange sentence: "Nature may be compared to a surface on which rest ten thousand sharp wedges touching each other and driven inward by incessant blows"—the idea being that any wedge that was relieved from blows would at once rise above the rest. But the comparison to wedges is not enough; we have to think, as it were, of *living* wedges, each with a will of its own—a will to rise, and then we have got nearer the idea of the struggle for existence. Nature is always sifting or winnowing, and this is expressed in another famous sentence of Darwin's: "It may be said that natural selection is daily and hourly scrutinizing throughout the world the slightest variations" or novelties. The

terrible side of this is pictured in Robert Louis Stevenson's *Woodman*:

> So hushed the woodland warfare goes
> Unceasing; and the silent foes
> Grapple and smother, strain and clasp
> Without a cry, without a gasp.
> Here also sound Thy fans, O God,
> Here too Thy banners move abroad:
> Forest and city, sea and shore,
> And the whole earth, Thy threshing-floor!
> The drums of war, the drums of peace,
> Roll through our cities without cease,
> And all the iron halls of life
> Ring with the unremitting strife.

But the struggle for existence is much wider than all this. As Darwin said: "I use the term in a large and metaphorical sense, including the dependence of one being on another, and including (which is more important) not only the life of the individual, but success in leaving progeny." So when a long-tailed tit gathers over two thousand feathers to line its nest, with the result that its children have a safer cradle and a better start in life, it is illustrating the struggle for existence just as much as does a sparrow-hawk which becomes clever enough to seize a sparrow out of a group on the ground without stopping for an instant in its headlong flight. Both are answering back to difficulties, but in different ways.

What is sometimes called the other side of the struggle for existence is really part of the struggle for existence which includes caring for others as well as caring for self. It includes giving more

milk to the young ones as well as sharpening teeth and claws. It includes all the new moves in parental care, in the kindliness of kindred, in co-operation and mutual aid. Instead of making a contrast between "struggle for self" and "struggle for others," it is more accurate to see that endeavours in either direction are among the possible answers back that living creatures make to the difficulties and limitations that beset them. In many cases the kin-instinct is as clear and as commanding as the self-preservative instinct, and, in critical situations, a solution may be found along either line or along both. The world is indeed the abode of the strong, but it is also the home of many feeble folk who make up in love what they lack in strength.

Ants are a little people, and all the world is against them, but they have found success in forming societies, and they are dreaded by much stronger animals, even beyond the class of insects. Every one knows that some kinds of ants go to war and have great battles. But our picture of nature must take its colour not only from the warfare, but also from the other-regarding activities which the whole life of the ant-hill illustrates. In many cases it seems to be a law that an ant with a full crop must never refuse to feed a hungry comrade.

Mr. W. H. Hudson tells of the Viscachas—burrowing rodents of South America—that when a farmer destroys a burrow and buries the inhabitants under a heap of earth, other Viscachas, coming from a distance—for there are frequent visits between village and village—dig out and save those that

have been buried alive. There are thousands of facts like this, which show that there is much more in the animal world than "Every one for himself and extinction take the hindmost." There are gregarious animals that live in flocks and herds, like wild cattle and horses ; there are social creatures that have genuine communities, such as beavers and rooks. Apart from gregarious and social animals, there is much co-operation. Little birds, like wagtails, will combine to drive off a falcon, and there are many instances of the disappointment of birds of prey when they visit a lake-side crowded with ducks and terns and plovers. It is quite certain that success in the battle is not always to the strong. Clever sociable birds, like rooks, cranes, and parrots are very safe. As Prince Kropotkin said : "Mutual aid leads to mutual confidence, the first condition for courage, and to individual initiative, the first condition for intellectual progress."

Of course it is true that mutual aid pays, and that we do not know how far we dare use such a word as "good" or "unselfish" in regard to animals. But the fact is that a large part of the time and energy of living creatures is devoted to activities which make not for self-advancement but for the welfare of the kind. So the struggle for existence is much more than a squabble around the platter, it rises into an endeavour after well-being—with others as well as self as its object. If we look to Nature for lessons, we see unceasing condemnation of slackness, of the "unlit lamp and the ungirt loin," and unceasing reward of struggle and

endeavour. But the struggle includes more than increased competition, it includes, just as prominently, increased combination and mutual aid. Nature has rewarded both these lines of solution with success and survival, but the line of mutual aid and sociality has been especially associated with the improvement of brains and good-will, and it is the line which we must especially follow.

NUMBER XXXVIII

THE NATURALIST'S FOUR QUESTIONS

THE naturalist's first question, however learnedly he may put it, is one of the child's first questions, asked long before it can speak: *What is this?* In how many different tones—of fear, of awe, of wonder, of inquisitiveness—has this question been asked since man and science began! Was it not Aristotle's question when a new specimen was brought to him? Was is not what Darwin asked first when they sent him one of the barnacles he was so fond of studying? Was it not the continual question of the naturalists on the great Columbus voyage of the *Challenger* which discovered the new world of the Deep Sea? Is it not the question on the lips of every teacher and student of natural history to-day?—What is this? It seems a "simple question," but how hard to answer when we insist on seeing even the outside of an animal with perfect precision, when we press it farther and farther home, from external features to internal structure, from organs to tissues, from tissues to cells. How intricate the answer becomes as we put one lens after another in front of our own, when

we call to our aid all sorts of devices for seeing more clearly. "What is this," we say, "in itself and in all its parts? What is this by itself and when compared with its fellows and kindred?" and our answer broadens and deepens till it furnishes the raw materials of one quarter (the anatomy quarter) of the whole science of Life-Lore—or Biology.

Close upon the first question, What is this? there rises a second—*How does this work?* The two questions are equally natural and equally necessary, and the science of living creatures makes most progress when they are not far apart. They prompt one another to more and more penetrating inquisitiveness. The key-word of the one is structure or make-up; the key-word of the other is function or activity. The creature that the first question killed and picked to pieces has to be put together again and made to work. What does it do? How does it do it? How does it go? How does it keep agoing? How long can it go? How does it cease from going? In other words, how does the living creature feel and move? How does it grow and multiply? How does it waste, recover itself, and finally, in most cases, die? Above all, can we find out anything about the secret of its activity and of its power of answering back in a purpose-like way to the changeful circumstances of its everyday life? These questions are all just different forms of the question which that great genius, Professor Clerk Maxwell, used to ask with much persistence when he was a boy: "What is the go of this—the particular go of this?" The answers

form the raw materials of another quarter (the physiology quarter) of the science of Life-Lore or Biology.

The third question is, *Whence is this?* and, though it may have been as old as the others, the answering of it is very modern. It is really a double question, for we may inquire into the life-history or development of the individual living creature, or we may inquire into the race-history or evolution of the group to which the particular creature belongs. That is to say, we may study the child-creature in its cradle and early days—the tiny beginning of the plant inside the seed, the bee-grub in the comb, the young skate in its mermaid's purse, the tadpoles in the pond before they are in the least like frogs, the unhatched chick within the egg-shell—and the answer to the question, Whence came this individual living creature as a whole and in each of its parts? is the science of life-history (embryology). Or we may study fossils which are the remains of the forerunners of present-day plants and animals, and this history of the race, as it is hidden in the rocky graveyards of the buried past, makes the science of race-becoming (palæontology). The two together go to make up a third quarter of Life-Lore.

There remains a fourth question, also very ancient, but it has only begun to be answered: *How have present-day living creatures come to be as they are?* The present is the child of the past, and the plants and animals living around us are the descendants—the changed descendants—of plants and animals, on the whole simpler, which lived before them and

gave rise to them. All through the ages, for millions and millions of years, novelties have been cropping up among living creatures, just as we know that they crop up to-day among pansies and pigeons. Some of these new departures came to stay and others never took grip. The fourth question inquires into the origin of the new departures and also into the way the raw materials have been fashioned to shape and use. But in this quarter of the science of Life-Lore only the foundation-stones have been laid.

NUMBER XXXIX

THE WHITE WINTER COAT

WHEN winter draws near we think of a change of dress. We clothe ourselves in the skins of other mammals, putting on layer after layer of wool, and, it may be, a fur coat on the top. Similarly many mammals grow a thicker and longer coat of hair as the days become colder. But there is also in some creatures a change of colour to white, as we see it, for instance, in the mountain hare, among mammals, and in the ptarmigan, among birds. How does this change come about, and what is its meaning?

Changing to white in winter is exhibited by distinctively northern creatures—the Arctic fox, the Hudson's Bay lemming, the ermine, the mountain hare, the American hare, and the ptarmigan. This is interesting, since permanent whiteness is characteristic of many northern animals, such as Polar bear and American Polar hare, Greenland falcon, and snowy owl. It is likely, therefore, that changing to white is advantageous for the same reasons as permanent whiteness.

Some of the mammals that usually turn white do not always change, and this is connected with

the habitat. Thus the Arctic fox does not usually turn white in Iceland; the mountain hare rarely changes in Ireland; and white stoats or ermines are comparatively rare in England. The suggestion is that the changes which bring about the whiteness require a considerable degree of cold to pull the trigger, as it were. It does not by any means follow that the cold is the direct or mechanical cause of the whiteness.

To the question, What actually takes place when the white dress is put on? a fairly secure answer can be given in some cases. But in other cases we have not as yet sufficient data. It is well known that the stoat or ermine, which is brownish-red in summer, usually becomes a beautiful white in winter, all but the black tip of the tail. How is this effected? In the main, the white hairs of winter are new hairs that take the place of the coloured hairs of summer. In the mountain hare, the white hairs of winter are partly new growths and partly the coloured summer hairs changed. The same is true for the American hare.

In a famous experiment made by Sir John Ross, a Hudson's Bay lemming was kept in the cabin of the ship through the winter and did not change colour. But on the first of February it was exposed on deck and it had several white patches next day. It turned white in a week, and died a few days afterwards. In this case the blanching must have been due to a change in individual hairs, such as sometimes occurs very rapidly in man as the result of a nervous shock.

The whiteness of hair or feathers is due partly to the absence of the usual pigment, and partly to the presence of minute gas bubbles in the cells. The whiteness of grey hair is thus in a way like the whiteness of foam.

There appear to be various advantages in a white dress in very cold snowy regions. For a hot-blooded animal, with a temperature high above that of the surrounding world, the loss of heat is less with white hairs or white feathers than with any other colour of dress. This is probably the chief advantage of turning white in winter, but it must also be admitted that a white dress is the least conspicuous dress in snowy regions as well as the most comfortable.

Where the struggle for existence is keen, it may be but a little thing that decides whether the creature is to survive or to be weeded out. Professor Davenport had 300 chickens in a field, 80 per cent. white or black and conspicuous, 20 per cent. spotted and inconspicuous. In a short time twenty-four were killed by crows, but only one of the killed was spotted. In this case the quality of whiteness was disadvantageous, but in the north or among the mountains those animals that turn white in winter are likely to have their chances of life improved.

No better example of a victorious creature could be given than the snowy owl, a native of the barren grounds of the Far North. It is a big bird, about two feet in length, of white plumage with variable dark spots and bars; it has a strong and easy flight, and hunts by day, picking up snow-birds

like the ptarmigan, snow-mammals like the Alpine hare, besides lemmings and mice, and even fishes. It has a wide distribution and a successful life; it seems indifferent to storms, except in so far as they destroy its food; it is wary but fearless, and a pair of them will attack a man who comes near the nest among the reindeer moss. The male is said to feed the mother and her large brood. The harmony between the plumage and the snowflakes is but one expression of the successful balance that this great bird has struck between its own strong nature and the hardness of the outer world. "The cry, seldom heard, is wild and wailing," but it is a cry of victory, for the bird has overcome its difficulties and is master of its fate. There seems a suggestion of this in its fierce eyes.

NUMBER XL

NATURAL HISTORY OF THE OTTER

THE otter is so shy a creature that few naturalists have had more than glimpses of its everyday (or rather, every-night) life. But its natural history has been finely studied in Mr. J. C. Tregarthen's *Life Story of the Otter*, on which we must for the most part rely. The question with which we are especially concerned is how the otter manages to hold its own, even in countries like Britain where so many of the finer wild mammals, such as marten and wild-cat, have become very few and far between. It is not enough to refer to the otter's cleverness, its keen senses of sight, hearing, touch, and smell, its muscular equipment, so marked in the grip of its jaw, the back-stroke of the hind-legs, and the sweep of the steering tail, for the two mammals we mentioned above are not deficient in these qualities, and yet their present-day tenure of life is much less secure than the otter's.

What particular virtues has the otter that enable it to keep its foothold in spite of man's persecution and the dwindling of wild places? The general answer is that the otter has comparatively few wild enemies, and that it is in great part nocturnal in

its activities, shy of repeating itself, shifty in its hunting, and very thoroughly at home in the water as well as on land. Mr. Tregarthen calls attention also to the faintness of the otter's scent, "noticed by few dogs save hounds that have been trained to own it," and to its resourcefulness and endurance when hunted. Part of the secret of survival must also lie in variety of its food, for while it depends in the main on eels, trout, salmon, pike, flatfish, and the like, it condescends to the mussels on the seashore (biting through their shells), the limpets on the rocks, and the frogs on the marsh, and rises to wild-duck and rabbit.

One of the admirable qualities of the otter is its parental, especially its maternal, care. The young ones—blind and downy—are born in a soft-lined nest under the shelter of a bank difficult to get at; the mother will at first hardly leave them save on rushes after the food necessary to keep up the supply of milk. To guard them she sleeps, like many a human mother, with at least one ear awake. When they open their eyes she cautiously carries them to bask for a while in the winter sunshine, for they are usually born in midwinter. When they can clamber she teaches them the woodcraft of the neighbourhood and the complete alphabet of the sounds that mean danger. With her teeth she punishes disobedient foolhardiness—especially on the part of the male cubs—yet she shares in their frolics when danger is distant. When they are a little over eight weeks old and able to follow her afield, she takes them to a quiet pool and teaches them to swim. In about

a week they can swim with the fishes—a week which seems more like play than school, for the otter is one of the animals in which there is prolonged playfulness in youth. Who shall say that the mother does not in some measure renew her youth as she shares in the "hide-and-seek" and gambols of her cubs? It is indeed a remarkable fact in regard to this fascinating animal that playfulness never quite leaves it; that even the fathers and mothers of families cannot resist the appeal of situations that suggest a frolic, and that they will play up to the very gates of death—"most playsomest critturs on God's earth," said one of Mr. Tregarthen's Cornish friends.

To return to education, the young cubs have also to learn to like the taste of fish, to catch them without fuss, and to eat them in the proper way—the eel from the tail and the trout from the head. They have to learn how to catch frogs and how to skin them, for the outside is unpleasant; how to guddle for trout and eels; how to detect the plaice in the shallow waters of the bay, hidden in or against the sand, with only their eyes showing. They have to learn how to deal with rabbit and moorhen, and, through it all, they have to keep working away at the long alphabet of danger-sounds—especially those coming from man and dog. They have to learn all the ways of lying hidden in and out of water. There can be no doubt that the long youth and the careful teaching count for much in the survival of the otter.

Another attractive feature about the otter is its

roving spirit. "The homeless hunter," Mr. Tregarthen calls it, "the Bedouin of the wild." "It has been known to travel fifteen miles in a night, and not infrequently the hiding-places where it lies up during the day are ten or twelve miles apart." It passes from tarn to stream, from river to shore; it swims far out to sea and reaches rocky islands; it wanders along the cliffs and explores the caves; it crosses the heather-covered hills, and even the mountain passes, sheltering among the bracken or in the heart of a cairn; it neither stores nor hibernates, but is always on the move—a gipsy among carnivores.

Resourceful is the right word for an otter. For it is equally at home on land and in water, by night and by day, in a dry burrow or on a shelf under a waterfall; it can enter the water without a splash, swim near the surface with scarce a ripple; it can dive in a spiral full fathoms five, and lie under the bank of a stream for hours with its nostril in a space between water and earth. It knows its own footsteps in the thicket and will not retrace them; it never goes back to a kill, for that way danger lies; it will carry a water-trap on its shoulders and wrench it off on the alder-roots; it will dive at the flash of a gun and elude the bullet; it is an outlaw of matchless alertness and resource.

The severest of tests is a hard and prolonged frost. At first it gives an added spice to life, for strings of wild-fowl arrive, and the ice on the mere is a rare playground. It is possible for the otter to hunt for pike beneath the ice, for eels and tench buried

THE OTTER BY THE STREAM.

deep in the mud. But there may be terrible experiences when the breathing holes in the ice freeze quickly and the otter is imprisoned below, when the parents are tied down by cubs too heavy to carry and not strong enough to travel, when the wild-fowl leave the sealed waters for the shore, when the snow threatens to smother the family. It is only in such straits that the otter, in desperation, begins to experiment by nights with the farmer's ducks. This last resource is very restricted, however, and the conditions may prove at last so severe that the mother dies in spite of all her efforts to get food for herself and her offspring.

Printed in Great Britain by Butler & Tanner, *Frome and London*